ISSN 1742-1705 Volume 22 Number 1 March 2007

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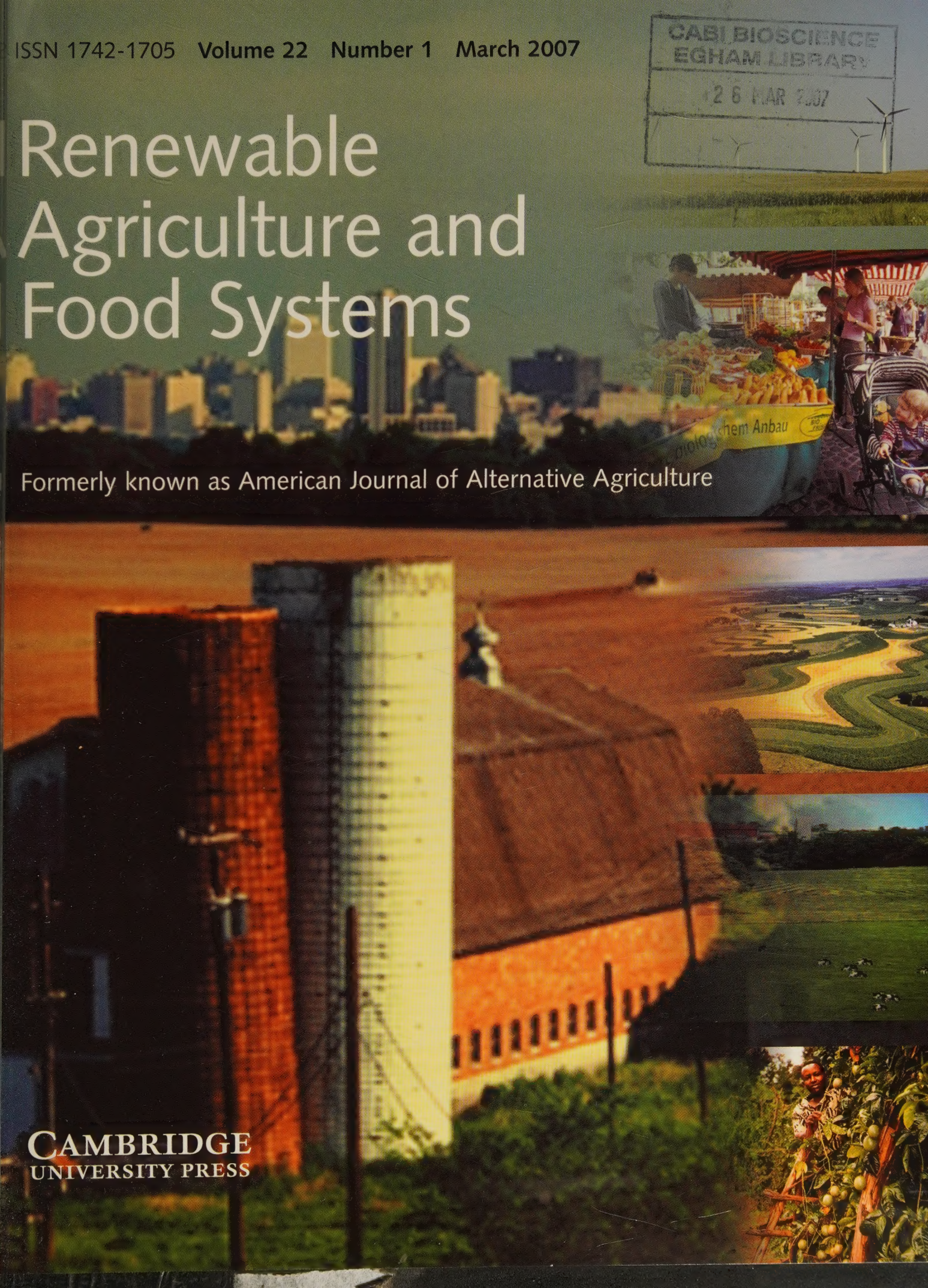

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Renewable Agriculture and Food Systems (ISSN 1742-1705) is published four times a year in March, June, September and December. The subscription price for institutions of Volume 22 (2007) which includes electronic access and delivery by air is £143 (US $262 in the USA, Canada and Mexico); the electronic only price for institutions is £110 (US $199 in the USA, Canada and Mexico). Single parts are £36 (US $66 in the USA, Canada and Mexico), plus postage.

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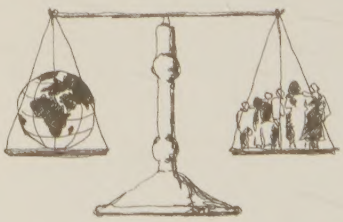

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Renewable Agriculture and Food Systems: 22(1); 1–10 doi:10.1017/S1742170507001500

The influence of a shift from conventional to organic olive farming on soil management and erosion risk in southern Spain

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Accepted 6 December 2005 **Research Paper**

Abstract

Natural resource conservation should be fundamental to organic agriculture, including the prevention of soil erosion. Soil erosion in the olive orchards of southern Spain is recognized as a serious problem causing environmental, economic and social repercussions, both on and off-site. This study describes the changes in soil management practices that accompanied a shift from conventional to organic olive farming and the corresponding effect of those management practices on erosion risk in the province of Córdoba, Andalusia. Interviews with 107 farmers were carried out in two different geographic areas to assess the socio-economic factors influencing farm management decision-making, and on-farm erosion risk evaluations and soil data (organic matter, aggregate stability, infiltration and vegetative ground cover) were taken on 25 farms to assess the effects of those decisions on soil erosion risk. Results from this study show that the shift to organic farming in olive orchards in the province of Córdoba has been accompanied by increased protection of the soil and lowered erosion risk. The most important changes in soil management practices associated with the transition from conventional to organic agriculture were the reduction in tillage and the increase in management systems that incorporate a vegetative cover controlled either by grazing livestock or mowing. However, the shift to organic farming has had more impact in the south of the province than in the north where farm management systems have historically led to less erosion.

Key words: organic farming, erosion, soil management, socio-economic influences

Introduction

A shift from conventional to organic agriculture should promote the conservation of natural resources and the development and use of sustainable farming practices, not just the prohibition of synthetic fertilizers and pesticides[1]. Soil and water are the world's most important natural resources, and their careful management should be paramount in organic agriculture. In the erosion-prone Mediterranean region, prioritizing soil conservation is key to sustainable farming, where soil organic matter (SOM) levels are inherently low[2], and the loss of existing organic matter contributes to a rapid decline of soil fertility, degradation of soil structure, and an increased risk of erosion[3].

The severe problems of soil erosion become evident on a drive along any road in the olive-producing areas of Andalusia, southern Spain, where olive trees dominate the landscape in an impressive monoculture that occupies 1.5 Mha, or 17% of the total surface area of Andalusia[4]. In a region often subjected to torrential rainstorms, the most common soil management practice among olive farmers over the past few decades has been to maintain bare soil year-round, underneath and between olive trees, by means of frequent tillage and/or use of herbicides. These practices have led to serious problems of erosion, soil compaction, loss of soil fertility, sedimentation of waterways and contamination of potable water sources[5–7]. Soil degradation problems are expected to worsen as the total area of land devoted to olive production in Andalusia has

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Figure 1. Location of all organic farms and the two study areas in the province of Cordoba.

rapidly expanded and cultivation has intensified in response to farm mechanization, new harvesting technologies and European Commission policies promoting productivity increases[2,8]. Small farmers on marginal lands have found themselves unable to compete with the new mechanized production systems because of their higher production costs and lower yields. Bleak economic prospects, among other factors, have led these farmers to adopt alternatives to conventional olive growing, such as organic production[9].

Regulations for the certification of organic agriculture prohibit the use of herbicides or chemical fertilizers; therefore the change in the type of inputs used on the farm is inherent to the shift to organic farming. However, the changes in soil management practices and the effects on soil fertility and soil erosion risk are not as evident or well understood[10], nor are soil management practices regulated under organic certification. In conventional agriculture, degradation of soil structure and function due to tillage or erosion is often combated by further cultivation and application of additional inputs rather than remedial or preventative measures[11]. In organic farming, however, the dependence on additional inputs to make up for the loss of the natural fertility of the soil is unsustainable, and is more costly than in conventional farming, given the limited access to and laborious application of manure and high costs of organic fertilizer products[12]. Soil management practices on organic farms should encompass maintenance of the natural fertility of the soil and prevention of soil degradation[1].

Soil erodibility, defined as soil susceptibility to detachment and transport by agents of erosion, is highly influenced by soil management[13]. Farmers' management decisions affect soil surface dynamics, such as soil compaction caused by machinery or overgrazing, or protection of the soil by a vegetative cover[14]. The state of the soil surface in turn affects the hydrology of the orchard, determining water balance, runoff generation and soil erosion[14]. Surface compaction and surface sealing decrease rainwater infiltration[7], causing increased surface runoff and elevated risk of erosion[3]. The presence of a vegetative cover not only protects the soil surface, but also significantly increases the formation of SOM and the biological activity in soil, thereby improving soil aggregate stability and preventing the formation of a surface seal[15]. Vegetation also increases infiltration due to the increase of soil macroporosity, causing a decrease in surface runoff[16], and consequently a decrease in erosion risk.

Improved understanding of the relationship between farmers' decision-making about soil management practices and the risk of soil erosion can facilitate the development of appropriate soil conservation policies. This relationship needs to be examined from two perspectives: the rationale behind soil management decisions and the effect those decisions have on soil erosion risk. Little research has been done on the relationship between organic production systems and soil erosion[10], especially in the Mediterranean basin, and no previous studies have been conducted about soil erosion in the organic olive orchards of Andalusia, where the organic movement is relatively young, founded officially in 1991. There are over 32,000 ha devoted to organic olive production in Andalusia at present, accounting for 38% of the total area devoted to organic agriculture[17]. The majority of organic olive orchards in Andalusia, more than 17,000 ha, are located in Córdoba[4], mostly in the north of the province (Fig. 1).

We conducted a field study with three objectives: (1) to describe the change in soil management practices that have accompanied the shift from conventional to organic

farming; (2) to analyze the soil management practices of organic olive farms in the Córdoba province as influenced by farm size, economic dependence on farm and geographic location; and (3) to investigate the relationship between soil management practices and erosion risk on organic olive orchards in the province of Córdoba.

Materials and Methods

Study sites

Two geographic areas in the province of Córdoba were identified for our study, the olive growing area in the north of the province that we refer to as '*la Sierra*', and the olive growing area in the south that we refer to as '*la Campiña*' (Fig. 1). These two areas were selected to best represent the agricultural systems in the province due to their differing management systems, agro-economy, soil type and topography.

La Sierra is a mountainous area characterized by steep slopes of up to 70% and shallow soils of dominant associations Xerochrept/Haploxeralf and Xerochrept/Xerorthent/Xerumbrept[18] developed on slates of the Precambrian and of the Carboniferous periods[19]. Farmers in this area have traditionally carried out low-input management systems, using animal traction for tillage, and livestock in the olive orchards as a sylvopastoral system that offers natural weed control and soil fertilization. These orchards are very old (more than 100 years), planted approximately 8 m × 8 m to 10 m × 10 m, generally with only one trunk per tree, and are almost entirely rain-fed[4]. It is not common for farmers to plant a cover crop in addition to the natural vegetation. Farmers till on average once a year with either animal traction or chisel or disk plows. Tillage operations are generally carried out once after the first rains in the fall (October) and/or in February–March after the harvest and tree pruning is finished. When tillage is carried out by animal traction, contour plowing is almost universal. When mechanical traction is used, farmers till in the direction of the slope or in a crossed pattern as to avoid tipping the tractor. This low-tech management system is due to the steep slopes and inherent low productivity of the orchards. Conversion to organic farming has been successful in this area in part due to the easy transition from the traditional management system to an organic system and the relative importance of the subsidies available for organic production compared to the income derived from the sale of olives[12]. In 2003, agricultural subsidies for organic farming in the province of Córdoba reached 3.7 million euros, almost entirely dedicated to olive farmers. This was equivalent to approximately an average of 150 euros per ha of olive orchards[17], in addition to the standard subsidies per kg of oil given to all producers. Without these subsidies, net farm profit would be negative in many areas of *la Sierra*[4].

The second study area, *la Campiña*, is characterized by rolling plains with moderate slopes generally below 25%, and deeper soils of dominant association Xerochrept/Xerorthent/Chromoxerert[18] developed mainly on marls and limestone–marl alternations of the Neogene period[19]. Farmers in this area generally carry out an intensive, high-input, high-tech management system on more productive farms compared to their northern counterparts. Orchards in *la Campiña* are newer than in *la Sierra*, and the surface area devoted to olive orchards is increasing[4]. Trees are planted from 12 m × 12 m in the most traditional orchards with three trunks per tree, to 6 m × 8 m (or 6 m) in the newer orchards with only one trunk per tree, and a significantly larger percentage of orchards are irrigated[4]. Farmers till on average three times a year with disk or chisel plows. Tillage operations are carried out after the first fall rains (October), to prepare the ground before the harvest (November–December), after the harvest and tree pruning (February–March) and sometimes again in mid-spring (April–May). Contour plowing is not commonly implemented, and on sloped farms tillage is often performed in the direction of maximum slope. The adoption of organic agriculture has been much less widespread in this area due to the relative unimportance of the subsidies compared to the income derived from the sale of olives[4].

Average annual precipitation is around 700 mm in *la Sierra* and 600 mm in *la Campiña*, in a typical Mediterranean distribution, with the rainfall concentrated mostly between November and March[19].

Farmer interviews

Semi-structured interviews were conducted with 107 randomly chosen organic olive farmers within the province of Córdoba to determine soil management practices, farm size and economic dependence on the farm. These 107 farms represent 9% of all of the organic olive farmers, in both geographic areas.

Soil management practices were divided into five categories covering all major soil management practices existing in organic olive orchards in the study areas (n = number of farms): (1) mowing (M), a mechanical form of weed management requiring mowing on average twice in the spring ($n = 10$); (2) intensive tillage (IT), tillage more than once a year ($n = 7$); (3) tillage (T), once or less than once a year ($n = 22$); (4) mixed system of tillage and livestock (TL), which implies tillage once or less than once a year and pasture animals as a form of weed control ($n = 37$); and (5) livestock (L), pasture animals as the sole form of weed control ($n = 31$). In this case, a livestock grazing system implies either owning the animals or leasing out grazing rights for other farmers' animals. The most common grazing animals are sheep.

We defined economic dependence on the farm in terms of the importance of income from olive cultivation (including subsidies) to overall family income. Three levels of economic dependence and three options for farmers not economically dependent on their olive orchards were defined, based on the information gathered in a preliminary

study to best represent the most important groups within the local olive farmers. The levels of economic dependence are: (1) total dependence on olives as the only source of income; (2) dependence on olive farming together with another source of income from an agricultural activity such as animal products (meat, cheese and milk) and other crops, or from providing agricultural services such as a tractor service, or olive milling; and (3) dependence on the farm together with another source of income from a non-agricultural source, such as a job in a city or town. The three options for farmers not economically dependent on olives reflect their motivations for maintaining olive production: (1) for cultural reasons; (2) for the extra income it provides from the harvest and the subsidies; and (3) both for cultural reasons and for the extra income. Farm size was divided into five groups: less than 5 ha, 5–20 ha, 20–50 ha, 50–100 ha and greater than 100 ha.

Measurement of soil characteristics

Fieldwork was conducted during the rainy season (mid-January to mid-March) over 2 years (2003–2004). Twenty-five farms were sampled, ten in *la Sierra* and 15 in *la Campiña*. More farms were sampled in *la Campiña* to represent better the greater heterogeneity (soil, socio-economic factors, etc.) in organic olive farms compared to farms in *la Sierra*[4,19]. To compare the condition of the soils under cultivation with undisturbed soil, measurements were taken in two locations on each farm: on a slope between two rows of trees within the orchard and on an adjacent slope in a nearby, undisturbed area whenever possible. In each location, the sample plot considered was a rectangular area in the middle of the slope (250 m^2); sample plots in the undisturbed locations were of equal size. While conducting fieldwork, it became evident that apart from the five soil management categories mentioned above, it was necessary to create another category given that some farmers claimed to carry out a mowing (M) system, but their farms had reached such a state of soil degradation that little or no vegetation grew. We refer to this group of farms as 'bare soil' (BS). We refer to the results from the undisturbed areas as 'natural soil' (NS) ($n = 14$). In total, the soil measurements are divided into seven categories.

Vegetative ground cover (VGC), SOM, cation exchange capacity (CEC), texture, aggregate stability, infiltration and slope were measured on each sample area of the 25 farms studied. In order to determine SOM, CEC, texture and aggregate stability, a composite sample of 30 sub-samples was taken (0–10 cm depth) in each sample plot. VGC was measured by estimating percentage of the soil covered by vegetation or vegetative residues in a 0.5 m × 0.5 m square, divided into four equal sections, in a total of 16 random locations in each sample plot, based on a percentage ground cover diagram from Herweg[20]. SOM was determined using the Walkley–Black method[21]. CEC was measured using the ammonium replacement method[22]. Texture was measured with the hydrometer method[23]. Aggregate stability was measured as percentage water-stable aggregates (WSA) of aggregates between 0.25 and 2 mm diameter[24]. Slope was measured with a pocket inclinometer. Olive tree canopy cover was determined by measuring the area projected onto the ground by the canopy (ten trees in each farm) in relation to the plantation density.

In 2003, infiltration was measured using the US Department of Agriculture (USDA) infiltration test[24] based on a simplified single ring test. In each sample plot, five rings (22 cm in diameter) were inserted 5 cm into the ground, 17 mm of water was applied and infiltration rate was measured when it became constant, following the USDA methodology[24]. In 2004, we modified the methodology for use on farms with steep slopes where water did not cover the whole soil surface area inside the ring. In this case, water was applied using perforated buckets as simplified rainfall simulators at a rate of 236 mm h^{-1}. Each ring had a tube built in at ground level that allowed for collection of the runoff. The results of the 2004 tests were standardized to the 2003 tests.

Erosion risk of the farms was assessed using a visual assessment derived from a methodology developed by Morgan[13], based on erosion symptoms. The assessment is scaled from 0 to 5, with 0 for no visual symptoms of erosion and 5 for a farm with serious rills, gullies, compaction, surface sealing or large areas with bare soil.

During the two study years (September 2002 to August 2004), the annual precipitation recorded on farms evaluated was 545 and 726 mm in *la Sierra*, and 534 and 568 mm in *la Campiña*.

Results

Changes in soil management from conventional to organic farming

Accompanying the shift from conventional to organic farming, there was a 46% decrease in farms managed with tillage (T and IT) and a 74% increase in the use of a sylvopastoral system (L and TL) despite the fact that these changes were not required by the regulations of organic certification (Fig. 2). Approximately two-thirds of the farmers who tilled intensively (IT) changed management practices when they converted to organic farming; one-half of the farmers that previously tilled intensively changed to a mowing system, and all of the farmers who previously mowed maintained their management system (Table 1). The only farmers that changed over to an IT system were those who previously used herbicides (Table 1).

Factors influencing soil management decisions in organic farming

All of the farmers who managed their farm with mowing (M), the majority of those who tilled intensively (IT) (86%) and those who tilled and had livestock (TL) (70%) depended economically on their farm (Fig. 3). The majority of the farmers who tilled less than once a year (67%) or

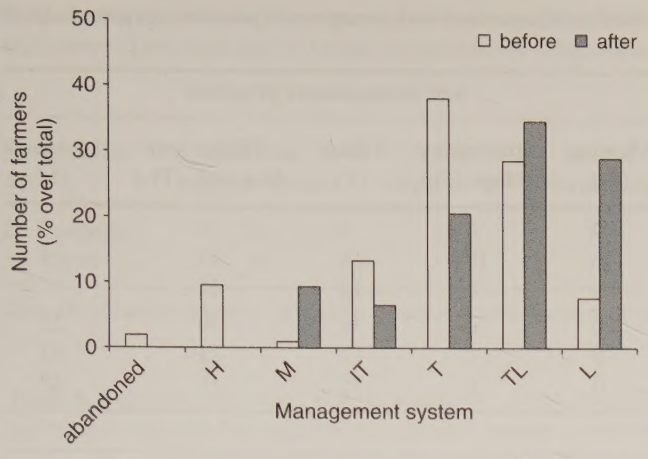

Figure 2. Soil management system before and after converting to organic farming (as % over total of farmers). H = herbicides, M = mowing, IT = intensive tillage, T = tillage once or less than once a year, TL = tillage and livestock, L = livestock.

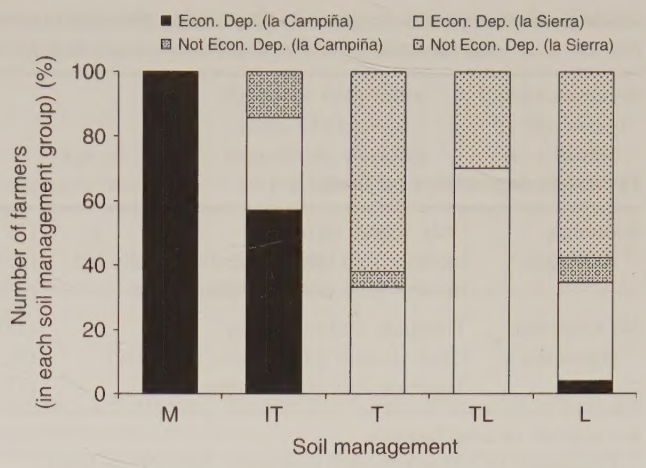

Figure 3. Relationship between soil management system and farmer's economic dependence on the farm, in *la Campiña* and *la Sierra* (as % over total of farmers for each management type). H = herbicides, M = mowing, IT = intensive tillage, T = tillage once or less than once a year, TL = tillage and livestock, L = livestock.

Table 1. Number of farmers (%) that changed soil management practices after the conversion from conventional to organic agriculture (for each management before converting to organic farming) ($n = 107$).

	After converting to organic farming				
Before converting to organic farming	**Mowing (M)**	**Intensive tillage (IT)**	**Tillage (T)**	**Tillage and livestock (TL)**	**Livestock (L)**
Abandoned	0	0	0	0	100
Herbicides	20	20	30	0	30
Mowing	**100**	0	0	0	0
Intensive tillage	50	**36**	0	0	14
Tillage	0	0	**48**	30	22
Tillage and livestock	0	0	0	**77**	23
Livestock	0	0	0	25	**75**

n = total number of farmers.
The numbers in bold represent the number of farmers who have not changed management practices.

managed their farm with livestock (L) (65%) did not depend economically on their farm (Fig. 3). Of all farmers interviewed, 43% did not depend economically on their farm, and of the farmers who did depend economically on their farm, 58% also depended on income from non-agricultural jobs (Table 2). Only 24% of all organic olive farmers depended solely on income from the olive farm and other agricultural activities. All of the farmers who depend solely on olive farming, mowed (M) (Table 2).

This relationship between soil management and economic dependence on the farm was associated with the farm size. Larger farms (more than 100 ha) were associated with mowing (M) (57%), whereas the most common management practice on small farms (less than 5 ha) was tillage (T) (52%), and on farms between 5 and 100 ha, farmers tended to use a livestock grazing system (TL or L) (Fig. 4a). The larger the farm, the more economic dependence farmers tended to have on the farm. All of the farmers with farms more than 100 ha in size and 80% of those with farms between 50 and 100 ha depended economically on their farm (Fig. 4b), whereas less than 20% of farmers with small farms (less than 5 ha) depended economically on their farm. On farms between 5 and 20 ha, economic dependency on the farm and on income from *non*-agricultural activities prevails (50%); however, on farms of 20–50 ha, economic dependence on the farm and on income from other *agricultural* activities prevails (42%) (Fig. 4b).

Results from the two geographic areas differed significantly with respect to farm size, economic dependence and management practices. In *la Campiña*, farms were larger, with an average farm size of 93 ha and 28% of all the farms having more than 100 ha, whereas in *la Sierra*, farms were smaller with an average farm size of 18 ha and 73% of the farms having less than 20 ha. Farmers in *la Campiña* tended to depend economically on their farms (78% of all the farmers) but in *la Sierra* farmers tended to rely more heavily on external forms of income (48% did not depend on the farm). In *la Campiña*, the majority of

Table 2. Main economic reasons for maintaining the olive organic orchards and associated soil management practices (as percentage of farmers over total for each economic dependence level) ($n = 107$).

Economic dependence on farm			Soil management practices				
			Mowing (M)	Intensive tillage (IT)	Tillage (T)	Tillage and livestock (TL)	Livestock (L)
Economic dependency	Only source of income	(1)[1]	100	0	0	0	0
	Income from other agricultural activities	(22)	18	18	14	41	9
	Income from non-agricultural jobs	(33)	9	6	12	52	21
No economic dependency	Tradition, culture, hobby	(18)	0	0	39	39	22
	Extra income (production, subsidies)	(8)	0	0	12	25	63
	Tradition and extra income	(17)	0	6	35	12	47

n = number of total farmers.
[1] Percentage of farmers in each economic dependence level.

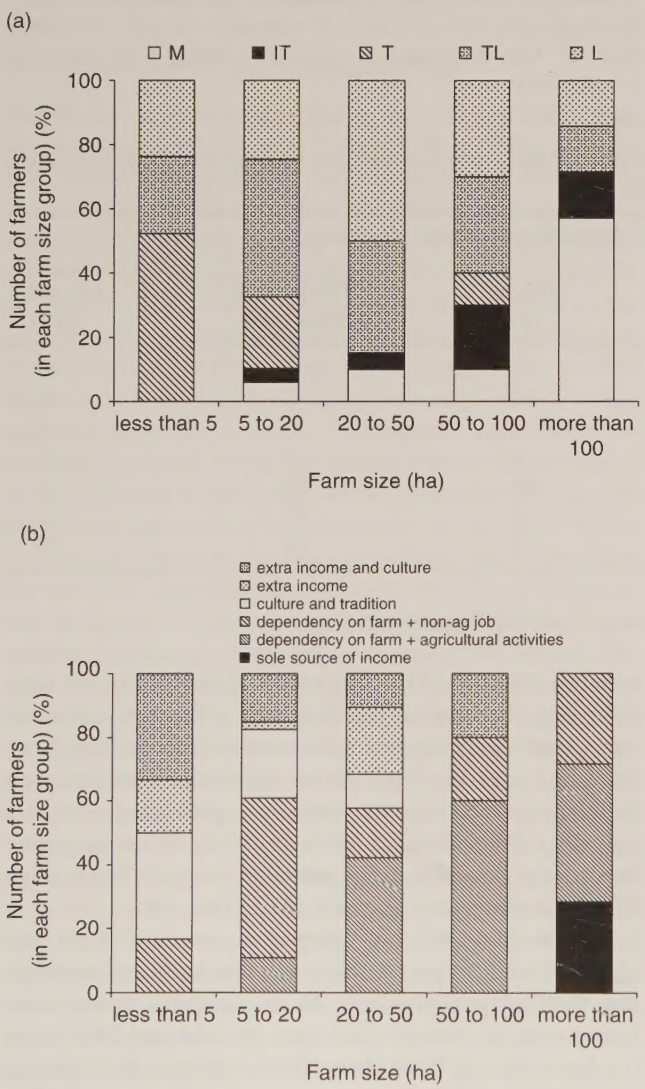

Figure 4. Distribution of (a) soil management practices, and (b) farmer's economic dependence on the farm, in each farm size group (as % over total of farmers for each farm size group). H = herbicides, M = mowing, IT = intensive tillage, T = tillage once or less than once a year, TL = tillage and livestock, L = livestock.

farmers mow (M) and till intensively (IT) (78% of the farmers), whereas in *la Sierra*, livestock (L) and TL were the most common soil management practices (73%) (Figs. 2 and 3). In *la Sierra*, farmers have farmed organically for more years, 93% of the farms are managed by family members, and farmers are on average older than in *la Campiña*. Average yields in *la Sierra* are significantly smaller than yields in *la Campiña* (Table 3).

Soil characteristics and erosion risk

The soil data taken on the 25 farms sampled are summarized in Table 4. VGC is highly related to soil management practices. The highest ground cover values are associated with L, TL, and M management systems, whereas the lowest values were found on farms with IT and BS management systems. SOM is highly associated with VGC in relation to farm management system. Despite the differences observed in SOM between management systems, these differences were not perceived in WSA, except in the BS farms with the most degraded soils that showed significantly lower WSA. However, there are important and similar differences in WSA between the natural and agricultural soils in both geographic locations (Table 4). Infiltration rates on L farms were significantly higher than the other management types, following the pattern observed in VGC and SOM results. The lowest infiltration rates were seen on farms with BS management systems due to their inherently compacted soils. Significant differences in infiltration rates were also observed between natural and agricultural soils in both geographic locations associated with higher SOM in the natural soils (Table 4).

The farms studied in *la Campiña* had principally clay loam soil textures as well as some loam soils; farms in *la Sierra* had sandy loam soil textures. CEC was directly related primarily to SOM as well as to the clay content of the soils (Table 4). The average slope for all of the sample plots in *la Campiña* was 16% (max 40%) and in *la Sierra* was 37% (max 65%). The average canopy cover on the

Table 3. Socio-economic characteristics of olive organic farms in the two geographic areas studied (averages): olive production per tree (kg), size of farm (ha), age of farmer, experience on farm, employees on farm, and years (average) in organic farming.

Geographic area	Years in organic (mean)	Yield (kg tree^{-1})	Size of farm (ha)	Age of farmers (mean)	Farmers with more than 10 years of experience working in the farm (%)	Farms managed by the owner or a family member (%)
La Campiña	4	35	93	38	49	62
La Sierra	6	7	18	50	67	93

Data from farmer surveys ($n = 107$), where n = total number of farmers.

Table 4. Soil characteristics[1]: VGC in winter (%), SOM (%), CEC (cmol kg^{-1}), WSA (%), and infiltration rate (cm h^{-1}) for natural and agricultural soils and for each soil management system, in the two geographic areas ($n = 25$).

Geographic area and management system	VGC (%)	SOM (%)	CEC (cmol kg^{-1})	WSA (%)	Infiltration (cm h^{-1})
'*La Campiña*' (clay loams and loams)					
Natural soil (NS)	n.a.	4.13 ± 1.11	18.3 ± 1.7	77.3 ± 3.2	94.4 ± 43.4
Agricultural soil (AS)	40.8 ± 8.3	1.85 ± 0.34	13.9 ± 1.1	55.7 ± 4.7	7.85 ± 1.50
'Bare soil' (BS)	21.8 ± 10.5	1.23 ± 0.38	11.8 ± 1.8	40.4 ± 3.3	2.39 ± 1.58
Mowing (M)	73.1 ± 5.6	2.44 ± 0.62	15.8 ± 1.3	60.1 ± 8.2	9.67 ± 2.47
Intensive tillage (IT)	2.7 ± 2.7	0.77 ± 0.11	11.4 ± 2.2	50.0 ± 12.0	7.28 ± 3.45
Tillage (T)	26.9 ± 12.6	2.22 ± 0.89	14.4 ± 4.4	71.1 ± 8.0	11.9 ± 2.73
'*La Sierra*' (sandy loams)					
Natural soil (NS)	n.a.	6.93 ± 1.32	19.4 ± 3.0	72.2 ± 2.7	60.0 ± 12.1
Agricultural soil (AS)	72.3 ± 8.8	2.76 ± 0.35	14.1 ± 1.4	54.2 ± 5.2	32.0 ± 10.4
Tillage (T)	18.6	1.21	7.44	33.2	44.9
Tillage and livestock (TL)	69.9 ± 9.2	2.87 ± 0.45	14.3 ± 1.8	55.1 ± 7.7	18.8 ± 2.4
Livestock (L)	95.0 ± 0.8	3.06 ± 0.59	15.9 ± 1.4	59.4 ± 3.6	54.3 ± 34.0

[1] Mean ± standard error.
n = number of farms.

farms sampled was 22% and 18% in *la Campiña* and *la Sierra*, respectively.

There were large differences in erosion risk between management systems (Fig. 5). Farms managed with IT and those with sparse vegetation cover (BS) showed higher erosion risk than those with M, L and TL management systems. Lower erosion risk was associated with higher percentage of VGC.

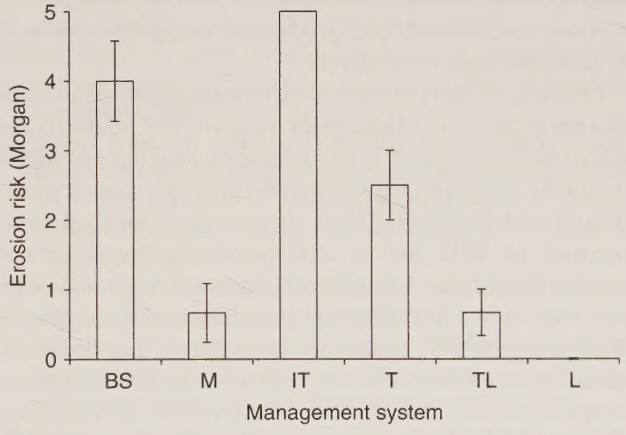

Figure 5. Erosion risk estimations based on Morgan[13] (0 = low risk, 5 = high risk).

Discussion

Our study has shown that the amount and frequency of tillage has decreased with the conversion to an organic cropping system (Fig. 2 and Table 1). Tillage in traditionally rain-fed olive orchards is considered necessary to avoid competition with the natural vegetation for water and nutrients, to reduce compaction and to improve infiltration. Control of vegetation by tillage also reduces the risk of wildfire during the dry season. Additionally, there are cultural reasons for which farmers till; many farmers still till so as not to have what their community would consider a 'dirty' orchard with weeds. While animals were the only source of power, tillage did not represent a significant threat to soil conservation in the region because of limited frequency and intensity of tillage. However, the extension of use of the tractor exacerbated soil erosion problems[5,7]. Careful management of weeds is necessary to avoid loss of production due to competition for water in a rain-fed system, but the presence of VGC is beneficial for the

protection of the soil against erosion, and for maintaining SOM levels, and soil structure[14–16,25]. There are several studies in Andalusia[26,27] showing that it may be possible to have vegetative cover without suffering a loss of production provided that the VGC is controlled adequately. Appropriate weed control in organic farming can be achieved by mowing or by grazing livestock. The shift to an organic production system has been accompanied by an increase in mowing in *la Campiña* and an increase in livestock in *la Sierra* (Figs. 2 and 3). There has been more adoption of mowing practices in *la Campiña* due to flatter slopes that facilitate the use of machinery and higher net profits that allow for greater economic investment in this area. The lack of a grazing tradition in *la Campiña* has also contributed to the increased adoption of mowing compared to *la Sierra*.

The two distinct groups of organic farms defined in this study (*la Sierra* and *la Campiña*) are differentiated by their location, soil type, agricultural history, socio-economic situation, farm size and yield potential. It can be seen from the results of this study that soil management practices are tied to geographic location (Fig. 3) and associated with economic dependence on the farm (Table 2 and Fig. 3) which is largely determined by farm size (Fig. 4). Sole economic dependence on olive orchards is not feasible in the mountainous areas of *la Sierra*, but is more common in *la Campiña* where yields per tree for organic olive are up to five times higher (Table 3) and the farms are almost five times larger. The farmers in *la Campiña* are also younger, have been managing the farms for fewer years and are more often employees of the farm and not the owners (Table 3). In accordance with our results, studies have shown that farmers with larger farms[28–30] and younger farmers more readily adopt new technologies[28,31], in this case associated with IT and mowing. All of these factors contribute to a more mechanized and productive cropping system in *la Campiña* than in *la Sierra*.

Overall, the shift to organic olive production has resulted in a net decrease in tillage (both intensive and minimal) and use of herbicides, and in an increase in mowing and use of livestock, alone or combined with tillage to control weeds (Fig. 2 and Table 1). These changes have resulted in an increase of VGC and a corresponding decrease in soil erosion risk (Table 4 and Fig. 5). Increase in ground cover has been shown to reduce soil loss dramatically in sloping olive orchards[32–34]. It has also been shown that additional reduction in erosion risk in organic systems with vegetative cover is achieved through increased levels of soil biological activity, SOM, aggregate stability and infiltration[10,35,36]. The results from this study show that differences in SOM, infiltration rates and water aggregate stability were significant between the management systems that have low VGC (IT and BS) and the other management systems that present values closer to those shown by the natural soils (Table 4 and Fig. 5).

Even though mowing systems had a high percentage of vegetative cover, infiltration rates in *la Campiña* soils remained low (Table 4). These low infiltration rates are most likely due to soil compaction as a result of excessive traffic and the compounded effect of the easily compacted clay textures of the soils in *la Campiña*. The effects that excessive traffic has on compaction and on soil loss[37–39] were not manifested in visual signs of soil erosion on the farms with mowing (M) systems evaluated in this study, due to the positive effect of the vegetative cover[39] and therefore the risk of erosion for the farms with this management system was low (Fig. 5).

Contrary to what would be expected, our erosion assessment indicated that the farms located in the steeper *la Sierra* showed less erosion symptoms than the farms located in the flatter *la Campiña*. Soils in *la Sierra* are slightly less erodable than soils in *la Campiña*; average soil erodibility rates (as defined for RUSLE[40]) are 0.03 and 0.04 t ha h (ha MJ mm)$^{-1}$ for *la Sierra* and *la Campiña*, respectively[41]. However, the large differences in soil erosion risk between *la Sierra* and *la Campiña* are most likely due to the prevailing management systems of grazing livestock and minimal tillage in *la Sierra*, whereas IT and heavy use of machinery on clay loam soils exacerbate erosion risk in *la Campiña*. Differences in erosion risk associated with these management practices (Fig. 5 and Table 4) are of the same magnitude or larger than the differences in soil erodibility[5] published for these soils. Even though a grazing system runs the risk of being erosive, we found that in general the farms with livestock did not show signs of overgrazing.

The shift from conventional to organic farming is still ongoing in the area, and the effects that it may have on a regional level may change with time. However, all of the farms sampled in this study have been managed organically for at least 4 years, sufficient time for soil properties to be affected.

Conclusion

This study shows that the shift to organic farming in olive orchards in the province of Córdoba has been associated with increased protection of the soil and reduced erosion risks. This was due to the decrease in soil management practices that may have a negative effect on soil conservation such as IT, and an increase in practices that have a positive effect, such as grazing livestock (L and TL), and mowing (M), systems that incorporate a VGC.

The organic farming initiative in the province of Córdoba has had a more important effect in *la Sierra* in terms of area of land affected by the change in soil erosion risk (Fig. 1). However, in *la Sierra*, the majority of the farms converted to organic are the farms that already had extensive, traditional management systems. The change in management systems and the impact on erosion risk was greater in *la Campiña*, as can be seen in the decrease in farms managed with IT, and an increase in farms managed with mowing. However, there is still an important percentage of organic olive farmers that manage their farms with IT and have high erosion risk levels. This is important in the

development of agricultural policy and certification guidelines of organic farming. With respect to soil conservation, rewarding farmers for organic farming can potentially decrease soil erosion risk if soil management practices on organic farms are monitored carefully.

Acknowledgements. The authors thank the farmers and the olive oil cooperatives that collaborated with this study, and the CAAE. J. Milgroom acknowledges a fellowship from the Fulbright Program who funded most of her stay in Cordoba during the course of this work. Financial support from the European Commission OLIVERO project QLK5-CT-2002-01841 is acknowledged.

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Renewable Agriculture and Food Systems: 22(1); 11–19 doi:10.1017/S1742170507001512

A new conservation education delivery system

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Accepted 16 December 2005 **Research Paper**

Abstract

The Conservation Agriculture Project (CAP) of the North Dakota Natural Resources Trust (Trust) has demonstrated a new concept for delivering conservation education that improves farm economics while enhancing environmental health, restoring landscape functions and providing societal benefits. The 5-year project, initiated by the Trust in 2000, incorporated Resource Analysis Teams to assist four farmers and farm families serving as a demonstration in developing and implementing holistic farm plans. Resource Analysis Team members were agricultural, environmental, conservation and economic professionals. Resource Analysis Teams met with each demonstration farm family twice each year in a non-threatening setting, usually around the family's kitchen table. The integration of diverse knowledge bases resulted in an educational roundtable with all participants being educators and students at the same time. As round-table participants became familiar with the intricacies of each particular farm and with each other, adversarial relationships dissolved and team members worked together to move the farms toward sustainability—economic, environmental and social. This approach differs from most federal conservation programs to date, which have approached on-farm conservation in a piecemeal manner, only protecting a parcel of land or a critical problem area. For those programs, responsibility for searching out and implementing conservation practices has fallen primarily on the farmer, who also has had to assume associated risks. The Conservation Agriculture Project has demonstrated that the Resource Analysis Team approach yields positive results for the environment, wildlife, farm families and society while enhancing information delivery and improving communication and acceptance among diverse groups with varying agendas. Most importantly, it has demonstrated the need and positive impacts of delivering conservation education directly to farmers and ranchers, who manage 43% of the land nationwide.

Key words: conservation, Conservation Agriculture Project (CAP), environmental education, resource teams, sustainable farms, whole farm planning

Introduction

Two divergent views have emerged on how to protect the nation's natural resources. The first approach attempts to protect them through governmental regulation. The second entails bringing farmers together with local agricultural, environmental and conservation experts to improve the natural resource base on individual farms.

The regulatory approach—whether rules are administered by the Environmental Protection Agency, the US Fish and Wildlife Service or state health department—has a tendency to raise animosity among farmers toward the responsible agency. Farmers often become indignant at the imposition and feel regulations are illogical, inflexible rules that are difficult to implement in real life. In this system, farmers receive conservation education from a variety of agencies and organizations, but they must seek out recommendations and often receive conflicting information.

To demonstrate the alternative, the North Dakota Natural Resources Trust (Trust) initiated Conservation Agriculture Project (CAP) in 2000. The mission of CAP was to demonstrate how a holistic team approach to farm planning, which includes economic, environmental and social considerations, enhances profitability while conserving natural resources for wildlife and society. CAP blended agricultural, environmental and conservation interests by simultaneously addressing the needs of farmers; local, state and national governments; and nonprofit conservation groups.

A Trust Advisory Board selected four farms in North Dakota's Drift Prairie Region to participate. Each farm

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family was assigned a seven-member Resource Analysis Team of agricultural, economic and conservation professionals. The Resource Analysis Team members met twice a year around the family's kitchen table to focus on creating an individualized, realistic and implementable plan that would produce desired results. This integration of diverse knowledge bases resulted in an educational roundtable with all participants being educators and students at the same time.

CAP has been a successful on-the-ground demonstration of how the use of Resource Analysis Teams provides a more effective method for addressing environmental, agricultural and economic concerns. It further demonstrates the need and positive impacts of delivering conservation education directly to farmers and ranchers, who manage 43% of the land nationwide.

This paper will describe the CAP model, discuss its results as described in exit interviews with the Resource Analysis Team members and demonstration farmers, and propose the adoption of this model through policy targeted toward beginning farmers.

The Need for a New Conservation Education Delivery System

There is increasing concern that current agricultural practices are negatively affecting human health and the environment. When contaminants from fertilizer, pesticides and soil erosion enter the air and water, they become detrimental to the health of farm families, surrounding community members and wildlife. These concerns are driving demand for a more sustainable form of agriculture. To achieve real results to that end, farmers and ranchers must have access to the education and information they need to shift their operations from more conventional management techniques and processes.

According to North Dakota agricultural statistics for 2002, 89% of the state's landscape is in agricultural use[1]. Nationwide, 972 million acres are farmed, or about 43% of the total landscape[2,3]. Because agriculture engages such a large portion of the land in the state and across the nation, it is critical for conservation education and application of that knowledge to succeed.

When conventional farmers move toward sustainability they shift their risks from effective available inputs to ecological systems management of the landscape, i.e., organic agriculture. To make these changes farmers are forced to take on significant risks that differ significantly from those to which they are accustomed.

Organic farmers do not have the option of quick-fix solutions to pesticide risks used by conventional farmers[4]. The organic industry requires specialized farm equipment and smaller storage units to accommodate broader crop rotations. There is the potential for genetically modified organisms to contaminate crops through cross-pollination, making them unfit for sale through the organic market. Most farmers cannot bear the entire risk and expense of good stewardship without an appropriate return for that investment. At the same time, no farmer wants to be the cause of degraded environmental quality. The availability of a good education program to make this transition is a must.

In the current system, farmers receive conservation education from a variety of agencies, including the Natural Resources Conservation Service (NRCS), Soil Conservation Districts (SCD), University Extension, the agricultural media and agribusiness. However, farmers must seek out recommendations and they often receive conflicting information.

The NRCS recognizes the need for technical expertise to support the district conservationist, who provides direct service and information to farmers. To address this, the NRCS has additional resource people available in its area (regional) offices, including soils classifiers, agronomists, engineers, wildlife biologists and program consultants. The inherent problem with this model is that only one person—the district conservationist, soil conservationist or technician—meets with the farmer. In most situations, it is a top-down system in which the agricultural or environmental professional is the authority and the farmer is considered the learner.

The Extension network has a similar structure, with a county agent backed by a university research team and a variety of Extension publications. This structure puts pressure on the professional to be the authority. In addition, it does not address farm issues as interconnected or from a whole-farm approach. Instead, these professionals address problems as isolated issues.

To have a significant impact on environmental health, restore landscape function and provide societal benefits, changes in conservation education programs should be directed toward farmers and ranchers[5]. The new conservation education model also should be designed to bring agricultural, environmental and conservation professionals together with farmers to focus on creating a whole-farm plan. This integration of diverse knowledge bases results in an educational roundtable with all participants being educators and students at the same time.

Conservation Agriculture

Central North Dakota wet cycle

In the late 1990s, North Dakota was in the midst of a 7-year wet cycle that was causing major flooding, planting and harvesting challenges and the spread of crop diseases related to wet conditions. The Drift Prairie Region of the Red River of the North Basin, located in central North Dakota, was particularly affected.

The Drift Prairie Region is characterized by low rolling hills and numerous prairie potholes, or small- to medium-sized depressed wetlands. These closed lakes, ponds and depressions, created by stagnant glacial ice, often are a

source of aggravation to farmers, who frequently describe them as 'wasteland'. Environmentalists, however, attribute a number of important landscape functions, such as lowered erosion, improved water quality and improved flood management, to these wetlands.

Conservation programs and farmers' attitudes

Generally speaking, farmers and ranchers have many concerns and conflicting ideas regarding water storage and conservation practices. They struggle daily with issues related to farm income, soil salinization, wetland designations and regulations, drainage and private property rights. Many private landowners become indignant at the suggestion that they are not providing the best care for the landscapes under their management. Because of this, they harbor anti-wetland views and animosity toward agencies and environmental groups that sponsor conservation of natural resources such as air, water, soil and wildlife habitat. Others believe that wetland drainage has no impact on flooding or are apathetic about the need to store water.

Farmers face many barriers to implement conservation practices. Those willing to engage in conservation programs have found it increasingly difficult to initiate and maintain practices. Economics drive their land use, and programs often do not provide adequate compensation for taking marginal land out of production; the high cost of implementing specific conservation measures are often prohibitive. Farm commodity programs and federal crop insurance programs promote market-driven crop rotations of corn and soybeans. As a result, a farmer who chooses to implement a long-term diversified crop rotation or other conservation practice assumes all the risks.

Many farmers also find it challenging, if not prohibitive, to deal with the bureaucracy inherent to implement multiple conservation programs. Past federal programs have approached on-farm conservation practices in a piecemeal fashion, only protecting a particular parcel of land or a critical problem area. Payments for conservation programs often compete with alternative programs. Federal programs are under-funded and farmers with less acreage cannot compete with larger farms for program enrollment. The programs farmers really like and use often are phased out and replaced with more prohibitive programs. The complex and ever-changing list of programs and requirements detracts from, rather than encourages, farmers' willingness to implement conservation practices.

Ultimately, all of these factors detract from adequate water storage and conservation, and point to the need for a new, more effective strategy.

Conservation agriculture takes shape

Farmers and community members came together in a series of meetings across North Dakota to address water issues related to the wet cycle of the 1990s. After listening to their concerns and frustrations with conservation programs and the overall agriculture climate, Roger Hollevoet, Devils Lake Wetland Management District director, developed the concept for Conservation Agriculture[5].

Hollevoet believed farmers should abandon their non-productive, problem farmland areas. He coined what would eventually become the slogan for CAP: 'Farm the best; alternatives on the rest'. Hollevoet reasoned that, for farmers to maintain profitability, they needed to have access to a team of advisors. This team would help them better understand the various programs available, as well as provide technical guidance and assistance to develop management efficiencies for improving the economic health and viability of the farm. Hollevoet suggested that the team include economists, agronomists, soils experts and conservation planners to advise on soil management, erosion prevention, wetlands development, crop selection and management, herbicide and fertilizer management, program selection, alternative land uses and minimum/no-till practices[5]. In 1999, Hollevoet presented his concept to the Trust for funding and management of a demonstration project.

Whole-farm planning

Whole-farm planning is not a new concept. The Savory Center[6], the Henry A. Wallace Institute for Alternative Agriculture[7], the University of Wisconsin-Madison[8], and others have all developed and advanced various holistic planning concepts and processes.

In 1984, Allan Savory developed Holistic Resource Management™ (HRM), a decision framework for resource management. It is based on the premise that all energy is derived from the sun, and it flows through plants which, in turn, capture water and minerals to produce 'marketable energy products' such as grain, livestock, fruits, vegetables, etc. Through HRM, effective sustainable management and goal setting focus on how to produce those marketable energy products efficiently on a sub-ecosystem basis, where the sub-ecosystem includes the farm and the people who live there. The Savory Center, a not-for-profit organization, offers tools, strategies, training, learning materials and a mentoring support network to help farmers and ranchers 'improve the quality of life and their bottom line (minimum economic need) while restoring the environment that sustains us all'[6]. This systems-based concept for 'agroenvironmental management' made sense to many professionals.

The Henry A. Wallace Institute for Alternative Agriculture helped define the whole-farm planning concept as an initial step to potentially influence national farm policy[7]. The Institute convened a roundtable of industry, government, sustainable agriculture and environmental interests to sort out definitions, goal-setting and implementation strategies for whole-farm planning. In response to the question, 'What are the features necessary for ensuring that whole-farm planning is an effective policy tool?' only two features appeared in the top five lists for each discipline.

Table 1. Characteristics of demonstration farms.

Landscape diversity
Farm diversity including livestock, crops, grassland and diversity in water resources
Landowner has a positive attitude and commitment to program objectives and is credible
Represent North Dakota farms with the primary income source being farming
Represent a diversity of watersheds with preferences placed on farms in specific locations within the watersheds
Farm has the potential to demonstrate conservation and wetland management
Best area for demonstration with easy accessibility for farm tours
Possibility for partnerships or cooperating with other programs or projects

First, whole-farm planning 'must be a voluntary option' and, secondly, plans 'must work at the ground level'[7].

The University of Wisconsin-Madison (UWM) adapted HRM concepts to a workshop module for training Extension educators, agency conservationists and nonprofit organization staffs. UWM's goal was to immerse professionals in the whole-farm planning concept and train them in the use of related processes to accomplish more effective planning with farmers and ranchers. The module's elements are compiled in a participant's workbook, 'Whole-farm Planning: an Overview Workshop,' and a facilitator's guide by the same name[8].

Technical team precedents

Hollevoet's proposal to the Trust board specifically recommended the use of technical teams to assist farmers with whole-farm planning. Two examples of the use of technical teams in the Upper Midwest already existed: the North Dakota Dairy Diagnostic Program and a monitoring program initiated by the Land Stewardship Project in Minnesota. Both suggested an initial basis for the structure of Hollevoet's team concept.

The North Dakota Dairy Diagnostic Program resulted from a 1997 North Dakota Department of Agriculture dairy summit. The summit focused on value-added animal agriculture for livestock producers, economic developers and financial lenders from across the state. Producers and representatives of service and support industries—power utilities, processors, regulatory agencies and individuals in public service, including the Extension Service—participated. The effort led to the Dairy Diagnostic Program, which was created by the North Dakota Legislature in 1999 through House Bill No. 1021.

The program's technical teams include a records specialist, a dairy nutritionist, a representative of a creamery and the county Extension agent. The program has one state coordinator. Participating dairy farmers define issues and set goals; technical teams survey the farms and propose solutions. Participants pay a fee based on the number of years they are enrolled and the number of cows they own[9].

The second program, initiated by the Land Stewardship Project in 1993, was a biological, financial and social monitoring project. Collaborators included researchers from the Minnesota Institute for Sustainable Agriculture, farmers from the Sustainable Farming Association of Minnesota and other agencies and individuals. In all, 24 monitoring project team members contributed expertise in soil science, plant pathology, wildlife ecology, hydrogeology, farm management, water quality, rural sociology, animal production (beef and dairy), crop production, agricultural economics, stream ecology, plant biology, on-farm research, management intensive grazing and HRM[10].

After documenting the farmers' management style and practices, the team supplemented them with new technologies and tools for making observations and recording progress. The team's methods, technologies and tools were compiled in the *Monitoring tool box*, which guides farmers to a future with a balance between the three elements of sustainability: economic, environmental and social[10].

Conservation Agriculture Methodology

The Trust's CAP Advisory Board selected four demonstration farms from 26 applicants. To qualify, a farmer was required to be engaged in a conventional management style. Advisory Board members also ensured that selected farms represented real North Dakota farms (Table 1).

After selecting the demonstration farms, the Advisory Board created a Resource Analysis Team for each farm family. Each six-member team included an Adult Farm Management (AFM) instructor, an agronomist, a soil scientist, a district conservationist, a wildlife biologist and a quality-of-life specialist. Selection of team members was based first on the resource people the demonstration farmers had worked with prior to the project. The project coordinator then selected additional professionals to fill any disciplinary gaps. When county-level personnel were unavailable, the project coordinator recruited regional personnel. This was the case for the farm management instructor, soil scientists and wildlife biologists. Some team members served on two Resource Analysis Teams. Each team included a local NRCS staff member.

CAP personnel collected and documented a range of information for each farm, including a farm description, all field maps, field rotations for the previous 4 years, a National Wetland Inventory, soils maps, and infrared vegetation images. The NRCS evaluated each demonstration farm for a Natural Resource Inventory and developed a Whole-Farm Conservation Plan.

Figure 1. Shown in front row are Deborah and Darrell Odegaard, Egeland, ND and members of their Resource Analysis Team (back row left to right) Terry Lykken, Rick Lee, Richard Mertens, Mark Fisher, and Jay Olson. Not shown is Gayle Gette, quality-of-life specialist.

Prior to a Resource Analysis Team meeting, the farmer and the project coordinator determined which issues needed to be addressed and the coordinator developed an agenda for the 2-h meeting. The project coordinator also forwarded documents to team members to inform them of specific issues to be covered prior to the meeting.

Resource Analysis Teams met twice each year in the farmers' homes with the exception of one farmer who felt his home was too small. His team met in the local Extension office conference room (Fig. 1). The project coordinator facilitated meetings, which began with an update from the farmer on his activities. Team members then addressed the topics they had been asked to prepare for the meeting.

In the spring, teams discussed soil samples taken the previous fall and planned for the upcoming cropping season. They also discussed the Adult Farm Management Analysis completed each spring, the results of the on-farm demonstrations from the previous year and any follow-up or new demonstrations being planned. In the fall, teams reviewed the successes and failures of the year and discussed what changes could be implemented the next season. They also reviewed avian surveys which tracked biological changes and were taken from mid-June to mid-July. Also in the fall, the quality-of-life specialist gave reports to the team. The reports were based on the results of exercises from the *Monitoring tool box*[10] designed to help families articulate their goals and values for the farm and their lives. This concept was new to an agricultural setting.

Major issues addressed by each Resource Analysis Team differed by farm (Table 2). In all cases, the demonstration farmer made final decisions regarding any actions taken on his farm.

Table 2. Major issues addressed by the Resource Analysis Teams.

Farm management analysis
Crop rotations and cover crops
Wetlands and saline soils, foxtail barley issues
Water drainage
Irrigation potential for dry edible beans
Improving soil quality and nutrient management
No-till/reduced-till practices
Long-range plan for transition of farm ownership/management
Iron chlorosis in soybeans
Biological control of soybean aphid infestation
Avian, invertebrate and plant surveys
Carbon sequestration monitoring
Bio-fuel potential
Pasture renovation and rotational grazing
Tourism income potential of birds and other wildlife
Quality of life exercises

Resource Analysis Team Results

CAP personnel gathered qualitative information through exit interviews with demonstration farmers and their Resource Analysis Team members to evaluate the effectiveness of the Resource Analysis Team concept. Although the data are not quantitative, these first-hand accounts will be valuable to agricultural education planners.

Exit interviews with demonstration farmers

CAP personnel asked each demonstration farmer to evaluate the value of his Resource Analysis Team, the return on his investment, and whether teams should be available to all farmers.

Each of the demonstration farmers agreed to participate in the program with apprehension. Initially, two issues motivated them to participate: the prospect of assistance in treating wet-saline areas and the project's incentive payments for set-aside acres. However, as the project progressed, farmers found the required AFM program interesting and beneficial. AFM is an educational program that provides group and individualized instruction for agricultural producers and their families to improve their marketing, risk management and business analysis. AFM also offers assistance in tax planning, year-end report preparation and a full-enterprise analysis at the end of the year. Farmers said AFM helped them to see the economic changes on their farms and to understand the positive economic impacts of the environmentally sound practices they were implementing.

Initially, the farmers were surprised that resource professionals were willing to take time just to talk about their farms. As the project progressed, trust developed and the farmers appreciated having such direct access to a range

of expertise to inform their decisions. The Resource Analysis Teams gently pushed the farmers toward protection of the environment by helping them envision the real application and potential of their ideas. One of the demonstration farmers described his experience as follows:

> I knew all of the people [who were members of my team], but when you bring them together for 3 h and you talk about issues and solutions, I kind of appreciated that. It isn't something I would have done on my own, nor would those team members spend as much time on an individual basis . . . I have seen lots of benefits to that [the team approach].

The broad knowledge base of the resource professionals resulted in a variety of perspectives and lively debates. The farmers became especially interested when professionals challenged each other over particular approaches to specific issues. These discussions helped the farmers consider many different management options by providing in-depth explorations of the possibilities.

Members of one demonstration family found the quality-of-life exercises especially beneficial and believe the exercises are important and central to a successful whole-farm plan. The process helped them raise important questions about their lives on the farm and, as a result, they realized the importance of a vacation away from the farm.

All of the farmers appreciated the Resource Analysis Team concept and said the process was worthwhile. One described the benefits this way:

> The whole Resource Team is learning in this process. My county agent is listening to the seed guy or soils guy and they are going back and forth. [This discussion] is really good and the whole group is learning more every meeting.

In addition, they all agreed the Resource Analysis Team concept should be offered in some format, funded either by state government or as part of the next Farm Bill.

Exit interviews with Resource Analysis Team members

In exit interviews with Resource Analysis Team members, CAP personnel focused on the following themes: expectations, positives, negatives, impacts on cooperators, impacts on the farm enterprises and impacts on the team members' professional capacities. Of the 20 Resource Analysis Team members, 17 completed an exit interview. With regard to expectations, two team members stated they were initially hesitant to get involved because they believed that little if anything would be accomplished. Others thought the resource would be a value to the producers and wanted to see how farmers would react. They felt that, if the process worked, it would be a great opportunity to meld farming and conservation.

Among the positive aspects of the experience, team members complimented the farmers for allowing the process to happen. They saw the farmers develop a spirit of cooperation and begin to rely upon their team's direction. As for the professionals, they appreciated being able to apply routine knowledge to a specific farm and follow the impact from year to year. The project also gave them an opportunity to get to know other agency professionals. Throughout the meetings, team members offered a variety of perspectives and the interchange of ideas was very respectful. They felt Resource Analysis Teams were able to offer more complete answers to farmers' questions. They described the quality-of-life exercises as putting the emphasis on the total picture, not just the planting and harvesting. One team member summarized the positives this way:

> Having six people with different professional backgrounds sit down with a producer and discuss various concerns that a producer might have and ways to help meet . . . objectives for the farm [is a positive]. I think just the interchange of ideas between people was a real plus. I know I learned some things even though I've been out in the field here for many years. I learned things I'd never been aware of before by listening to people with different backgrounds. It made me more cognizant of the fact that there's more to most things than I had a perception that there was [when] looking at it from my background.

Time was the most frequently mentioned negetative aspect of the Resource Analysis Team concept. Travel to and from the meeting and the meeting itself consumed half a day of work two times per year. For most professionals, the agency they work for covered this expense, but for those who were part of an independent business, the time and travel counted against their bottom line. Another negative cited was the fact that the project ended, and Resource Analysis Team support is no longer available to the participating farmers. Some team members felt that a six-member team was too large. While one team member described the quality-of-life exercises as an important aspect of the total farm management, others questioned their value. One team member said he found it difficult to work as a member of a team.

The farm management professionals were disappointed that they had to speak in generalities due to the confidentiality of financial information, while the soil scientist, agronomist and wildlife biologist could speak in specific numbers, e.g., pounds of nitrogen, number of pure live seed, or numbers of blue-winged teal.

One team member felt the whole-farm planning process had fallen short of the ideal outline for whole-farm planning. In reviewing the project, it is clear that funding was a limiting factor. As a result, the farm plans were progressive plans measured against NRCS Conservation Plans to protect the natural resources. However, it is also clear that this multidisciplinary and multifaceted Resource

Analysis Team approach to education changed farmers management to benefit landscape resources in a relatively short period of time.

Resource Analysis Team members agreed that, overall, implementation of the concept was very successful. They described the impact on the farmers as generating positive income, which absolutely affected the bottom line in a positive way and significantly impacted the farm families.

Team members also believed the interaction among a variety of professionals helped farmers to think about issues from different perspectives. As trust developed, farmers responded by being open to changes and showing a willingness to try new things, which made team members feel valued. At the same time, team members felt farmers were not overwhelmed and were able to represent their own perspectives proficiently. Team members said they also observed a change in farmers' attitudes toward conservation as the project progressed. An example of this is the fact that one demonstration farmer has agreed to serve on his county Soil Conservation District Board. In addition, team members felt that the exposure of the family to the biological aspects of the farm was a plus.

Resource Analysis Team members commented on CAP's impacts on demonstration farm enterprises by mentioning how the project generated real dollars. CAP gave the farmers economically viable options that allowed them to manage the land differently, including investment in minimum/no-till drills. This resulted in a substantial change in tillage practices, which had profound effects on the soil quality of fields. This, in turn, resulted in greater protection of the environment.

When asked if serving on a Resource Analysis Team had impacted their professional capacity, three team members indicated it did not while another said the adversarial relationship between wildlife/conservation organizations and farmers had eased. Another said:

> I was a skeptic coming into the project. We've had a long history of having an adversial relationship between the wildlife organizations and conservation organizations here in the Devils Lake area with all of our water problems. From my own perspective, it has helped my own attitude toward programs [like Conservation Agriculture].

Three team members said their exposure to other agencies' staff and programs has provided information they will share with other farmers with whom they work. While one team member, a field consultant, was skeptical of the soundness of collaborative recommendations, others said the project strengthened their belief in collaboration, and that the experience broadened their views and understanding of farmers and their families. The interaction helped them think beyond research plots to develop an appreciation for a larger operation and its cropping system. One member said he now has a better understanding of why farmers do not adopt diverse rotations and implement conservation practices. Another said he gained confidence in the value of his professional product (soil surveys).

Resource Analysis Team members overwhelmingly believed the concept should be available to other farmers. They agree this effort showed the economic loss of farming marginal ground and the positive effect of finding alternative uses for it. However, team members believed producers need a substantial reward or benefit to encourage them to hold up their management strategy for public scrutiny. They also agreed that the primary obstacles to this concept would be funding the teams and accomodating for the time constraints. As a group, they were unsure of how such a broadened team effort should be structured, and said available funding likely would dictate the final structure.

All but one of the team members said that they would be willing to serve again. He is a self-employed businessman and serving on the team took time away from his business.

Potential Obstacles to Resource Analysis Team Implementation

There are many potential obstacles to applying the Resource Analysis Team concept on a county, state, regional or national scale. They include funding, time, scheduling, the ability to recruit cooperative and knowledgeable team members, the ability to engage farmers who want to learn, and the availability of a skilled coordinator/facilitator.

Generally speaking, funding for this new farmer conservation education model needs to be addressed through public policy at the state and federal levels. The Farm Bill is one possible funding opportunity. However, states also need to be proactive in adopting and funding this type of conservation education program. Once the funding for the resource analysis teams and coordinators is secure then other programs funded by federal, state and private non-profits can be engaged to support the educational activities suggested by the resource analysis team members. Three examples of programs that were used by CAP were Agricultural Products Utilization Commission (APUC)[11], Sustainable Agriculture Research and Education (SARE)[12] AFM as described earlier.

On-farm demonstrations are an essential part of any program because they allow farmers to test different management techniques, and there are many small grant opportunities. In North Dakota, for example, producers can apply for farm diversification grants from the APUC[11]. CAP also accessed SARE grants, which are available nationwide. SARE provides farmers small grants for testing innovations that lead to more sustainable farming practices[12]. The AFM is available in several states in the upper midwest. It is funded by the ND Department for Career and Technical Education and the remainder of expenses are paid by the farmers and ranchers enrolled.

With regard to recruiting Resource Analysis Team members, the real issues are money and time. CAP demonstrated that the Resource Analysis Team concept

Table 3. Resource analysis team and coordinator's time approximations per farm family.

Resources per farm family per year	Time
Six Resource Analysis Team members × 2 h per meeting × 2 h travel time × 2 meetings per year + 12 h total preparation time Additional cost: mileage to meetings	60 h
Farm family time	10 h
AFM program cost: $500/year enrollment cost	25 h
Coordinator: enrollment, schedule, facilitate	48 h

would require a total of approximately 60 h of team time per farm family to engage six technical professionals for two meetings per year (Table 3). In the case of CAP, team members' time was donated, with independent business owners reinbursed for some mileage.

When recruiting Resource Analysis Team members, it is important that they be familiar with the individual farm, not only so they can make good recommendations, but also so there is an environment conducive to sharing opposing opinions about farm problems. Many agencies already offer professional assistance to farmers; when funds are available for projects, they allocate staff time or hire additional staff. To implement the Resource Analysis Team concept, they would have to allocate staff time.

Engaging a good coordinator/facilitator is essential because that person provides the links between the farmer, the Resource Analysis Team members and program providers. The coordinator/facilitator needs to have a strong agricultural background with excellent written and verbal skills. CAP required approximately 48 h per family per year for the project coordinator/facilitator to oversee program enrollment, schedule and facilitate meetings and follow through with on-farm demonstrations.

The nationwide Cooperative Extension programs comprise agricultural professionals trained to be effective facilitators, and most states have these professionals placed in each county. These Extension professionals could provide the needed facilitation for this project, if appropriate funding were provided for these activities.

Discussion

In 2000, in an area that has been in a wet cycle for 7 years, has had nine Presidential disaster declarations, and has experienced annual increases of wet-saline areas, CAP promised some relief.

The Resource Analysis Team educational model engaged a variety of people from agencies, nonprofits and businesses in working together for the benefit of farmers and the environment. The project broke down barriers between organizations, resulting in an atmosphere of real trust and communication. The varied perspectives from diverse professionals and farmers alike created multiple opportunities and choices for farmers, who might have a variety of skills but lack in one or two areas. By meeting on-farm, the Resource Analysis Teams came to the farmers and met in a somewhat neutral location where they were comfortable.

At the end of the project, the participating farmers all agreed the experience was beneficial. One farmer likened it to 'graduate school for farmers,' and one Resource Analysis Team member said CAP put a human face on regulations that guide environmental impacts. In exit interviews, both farmers and Resource Analysis Team members said this education model should be available to farmers and, at the very least, be available to a limited number of farmers. However, everyone involved in the project was concerned about its expense and the time constraints.

In addition to the educational and communication benefits of CAP, the project's incentive payments for the implementation of conservation practices allowed participating farmers to purchase tillage tools that will continue to impact their farm management. Farmers are finding that, when a no-till system reaches maturity, they can apply even less pesticide for weed control[13]. The ultimate results—less wind and water erosion and better soil quality—will continue to positively impact environmental quality for years to come.

Conclusion

CAP was a limited but highly successful demonstration of the Resource Analysis Team concept, which we believe could be the key to improve entire operations from a whole-farm perspective. Resource Analysis Teams successfully introduced concepts of sustainability and encouraged farmers to adopt more economically and environmentally sound practices, which benefit society as a whole.

Many technical resource professionals presently engage farmers and ranchers on the local level. In this demonstration, some resource specialists initially were reluctant to become involved with the project. However, as time passed these experts became active supporters, not only of the farmers, but also of the Resource Analysis Team concept. Most said the process was educational on a professional level. By participating, they gained a clearer understanding of farmers' perspectives and realities. We anticipate that other conservation professionals would also benefit from this experience. As a consequence, conservation programs would be more effectively designed and become more accessible to farmers. The agency representatives also

might assist in creating incentive payments that better reflect the true costs of restoring landscape functions and providing societal benefits.

There are numerous technical professionals in every state who are employed through federal, state and county agencies, agribusinesses, agricultural lending institutions and churches. All of these specialists will be potential team members once they understand the value of the concept and are compensated appropriately for their time and travel.

This new educational delivery model could be targeted to beginning farmers as a starting point for the proposed agricultural education reform. While three of the four CAP farmers plan to retire within 15 years, the program could be most beneficial for beginning farmers whose management practices are just starting to be shaped. In North Dakota, 80 beginning farmers requested loan assistance from the Bank of North Dakota in 2004–05. By tapping into this participant base, the farmers would be scattered throughout the state so that any one county would not be overburdened with the implementation of a new program.

This innovative education model will truly bring agricultural and environmental interests closer together, thus affecting real environmental protection by moving the farms in the direction of sustainability—economic, environmental and social.

Acknowledgements. We thank the ND Natural Resources Trust, the Environmental Protection Agency, the National Fish and Wildlife Foundation for the majority of the funding for this project. Thanks to Roger Hollevoet for the concept, for bringing it to the Trust for implementation and for serving on the advisory board. Also thanks to Martin Fredricks of Fredricks Communication for his editing skills, and to the demonstration farmers, Resource Analysis Team members, the Advisory Board and the many other partners who have engaged in this project.

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Renewable Agriculture and Food Systems: 22(1); 20–29 doi:10.1017/S1742170507001561

The importance of farmers' markets for West Virginia direct marketers

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Accepted 17 February 2006 **Research Paper**

Abstract

In the winter of 2004–2005, over 300 of West Virginia's farmers' market vendors were surveyed with regard to sales levels, promotional techniques and operational characteristics such as hours worked, types of products produced and length of season. Vendors were categorized based on part-time, full-time or retired status, and full-time farmers, both with and without off-farm jobs, were found to be distinct from part-time and retired vendors with respect to 2004 total farmers' market sales and the percentage of household income from farmers' markets. Econometric analysis [ordinary least squares (OLS)] was performed to identify the impact of explanatory variables on total farmers' market sales, percentage of household income from farmers' market sales and amount of household income from farmers' market sales. Independent variables such as bargaining, cost-plus pricing, selling at markets outside West Virginia and providing print materials were found to have a positive impact on annual sales. The number of products produced, distance traveled to market and number of weeks at market were also positively related to the percentage of income obtained from farmers' market sales. Both part-time and retired producers received a lower percentage of household income from farmers' markets relative to full-time producers. Retired and part-time, along with limited-resource vendors (with annual household income less than $20,000) were also found to have lower total sales in the 2004 season. Identifying the characteristics associated with greater farmers' market sales and a higher reliance on such sales for household income will help in the sustained success of markets as engines of economic development and small farm viability.

Key words: direct marketing, farmers' market, sales levels, farm income, promotional methods

Introduction

As concerns about farmland protection, small farm viability and the implications of an industrialized food system continue to mount[1], sales of agricultural products directly from farmers to consumers have been increasing throughout the United States in the past decade[2]. According to the most recent US Agricultural Census, the value of direct sales of agricultural products in West Virginia increased from $2.9 million in 1997 to $4.6 million in 2002, and the number of farms selling directly to consumers increased from 1303 to 1434[3]. As one of the most important venues for direct marketers, farmers' markets nationwide have increased twofold in number over the years, from 1755 in 1994 to 3706 in 2004[4]. This growth in farmers' markets and direct marketing is driven both by consumer demand for fresh, local products and by the potential for increased farm income. Farmers' markets are considered by many to be an especially important direct marketing outlet for small farms, yet few studies have examined the contribution of farmers' markets to the income of agricultural direct marketers.

West Virginia is a rural state whose agriculture is largely comprised of small family farms. Ninety-five percent of West Virginia farms are family owned and operated, and farms with annual sales of less than $50,000 accounted for 95% of all farms in 2002[5]. At an average of 69.6 hectares (172 acres), land base for the state's farms is small compared to the national average of 178.5 hectares (441 acres)[5]. While this density of small farms 'perpetuates the traditional quality of rural landscapes', it also means that few farming families can take advantage of the economies of scale that make extensive agriculture viable[6]. Preserving the state's agricultural base requires an attention to

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enterprises that are feasible on a small scale, such as fruits, vegetables and other high-value alternative crops.

Higher return per acre is one method of preserving small farms, particularly in the vicinity of growing metro areas, where prices received for products sold directly to consumers tend to be 'significantly higher than typical wholesale prices'[7]. Among the many benefits to farmers inherent in farmers' markets is the fostering of entrepreneurship, since the direct contact with consumers allows farmers to 'experiment with new items to respond to shoppers' demands'[8,9]. Farmers' markets play a vital role in enabling small-scale farmers to gain direct access to customers. Without this direct access to consumers, the existence of many small- and medium-size growers would be threatened, since smaller farms are more likely to use such direct marketing methods[7,10]. In the 2004 season, there were more than 30 farmers' markets operating in West Virginia[11].

The needs of small, diversified farm operations have gradually come to the attention of researchers and educators as they seek to identify the characteristics correlated with success in agricultural enterprises. The National Commission on Small Farms noted in their 1998 recommendations that small farmers are recognizing a need to add value to their products in order to boost economic returns[12]. If, as the Commission suggests, the fate of small farms and the businesses that rely on them will ultimately depend on 'the ability of a new generation to enter into farming,' then specific attention to the factors influencing financial viability is well warranted[12]. One of the largest limiting factors identified by direct marketers nationwide in a 2000 US Department of Agriculture (USDA)-sponsored focus group was a lack of business decision-making tools, including knowledge of the characteristics associated with success in various direct-marketing outlets[13].

The purpose of this study was to examine the impact of farmers' market sales on farm family household income for farmers' market vendors in West Virginia, as well as to understand factors that influenced total farmers' market sales in 2004.

Background

An earlier West Virginia study surveyed farmers' market consumers but not farmers' market vendors; the information gathered is nevertheless relevant for understanding vendor success. This 1984 study revealed that West Virginia residents prioritized quality as the primary reason to shop at a farmers' market, and limited volume or variety as a reason for dislike of farmers' markets[14]. Similarly, researchers at Rutgers University found that nearly 90% of New Jersey consumers rated the quality of products at farmers' markets as 'excellent or very good,' though only half rated variety of products as 'excellent or very good'[15]. A diverse selection of products can help fulfill shoppers' needs and encourage them to spend more each week[16,17]. Organic products add diversity to a market and often provide a price premium for producers. According to a New Jersey study, 64% of vendors surveyed said that customers were requesting organically grown products[18]. Addressing the diversity issue is important to market managers in Maryland, Washington, DC and Pennsylvania, who cited recruitment of vendors with certain value-added products as an urgent priority[19]. Yet only 33% of vendors in Oklahoma reported selling value-added products, and only 1.9% of all farmers in West Virginia are considered value-added processors[20,21].

Along with product diversity, the number of weeks local products are available via farmers' markets may satisfy customers and increase revenue and income for farmers. A national survey of markets conducted in 2000 revealed that 25% of those in the Mid-Atlantic were open year-round, with an average season length of 20 weeks[10]. Success may also depend on having repeat customers, receiving retail prices, personal interaction with customers, and high demand for high-quality produce[20,22]. Promotional methods are also likely to have an impact on farmers' market revenue and income. Posting signs indicating price and product information, providing samples and recipes, and offering bulk discounts were all methods used at many New Jersey and Oklahoma farmers' markets[20,22]. A large majority of New Jersey vendors indicated that they promoted sales by offering information on how to prepare produce, with even more of them inviting customers to sample their products[22]. Seventy-five percent of Maryland producers responding to a Chesapeake Fields Institute survey used one or more value-added labels when marketing their products, such as 'natural', 'free range' or 'fresh-picked'[23].

While direct-marketing presents opportunities to capture a larger share of the food dollar, suitable pricing methods play an important role in maximizing profitability when selling at farmers' markets[24]. Among the most common pricing methods used by Oklahoma vendors were grocery store comparison, matching other vendors' prices, and cost of production plus mark-up[20]. Marketers in New Jersey relied more heavily on comparisons with chain stores and wholesale markets as pricing methods rather than cost-accounting or mark-up methods[22].

Farmers' market sales may be an important source of income, especially for small farm households, as well as a way to develop business skills. Henneberry and Agustini[20] found that 49% of farmers' market vendors in Oklahoma had total annual household incomes of $39,999 or less. While 52% indicated that they did not work off-farm jobs during the market season, only 5% claimed that sales from farmers' markets constituted their full-time income. Among their survey respondents, 43% considered income from farmers' markets as part-time income, with another 27% considering it 'hobby' or 'extra' income. Feenstra et al.[25] found that farmers' markets promoted entrepreneurial skills for farmers from operations of all sizes, even though income from the market was only a small part of household income for small farms. A West Virginia University

(WVU) study of vegetable producers found that nearly three-quarters had annual vegetable income of $5000 or less[26]. A majority of farmers' market vendors at metro and small-town markets in California were full-time farmers, with more part-time vendors selling at rural markets[27]. Though income derived from New Jersey farmers' markets varied widely among respondents, with sales at markets comprising the entire income for some vendors, the overall mean was 37% of total gross income[22]. Direct-marketers in New Jersey who sell their products through direct-retailing were found to be 14% more likely to be in a high-income category compared to those who are not primarily retailers, and even higher for those selling value-added products like breads, pies or jams[28].

Our study builds on much of this previous work by examining the impact that promotional strategies, pricing methods, product diversity, length of market season and other market and vendor characteristics have on farmers' market sales. We also address the importance of farmers' market sales to farm households by analyzing the amount of income from farmers' markets as well as the percentage of household income accounted for by farmers' market sales.

Survey and Data

Vendors, identified by collecting contact information in person at West Virginia farmers' markets as well as from market managers, were surveyed regarding their 2004 season[29]. An additional list of 150 vegetable growers available from the WVU Extension Service was also used. All 331 members of the vendor population were included, regardless of their state of residency, as long as they used at least one farmers' market in West Virginia as a marketing outlet. Of the 331 distributed questionnaires, 236 were returned, for a response rate of 71%. Those respondents indicating that they did not sell any products at a West Virginia farmers' market in the 2004 season were removed from subsequent analysis, leaving 194 (59%) usable questionnaires.

Content and face validity of the survey was established by WVU faculty in Agricultural and Environmental Education and Agricultural and Resource Economics as well as by a small volunteer pilot group of vendors. Reliability of the instrument was determined based on alpha scale analysis of the sample population's data. Cronbach's alpha was valued at 0.9223, and the instrument was deemed to have exemplary reliability[30]. Each mailed survey was accompanied by a small gift, a hand-signed cover letter and a self-addressed stamped envelope. Following recommendations by Dillman[31], a second mailing of the instrument was sent to non-respondents four weeks after the initial mailing, accompanied by a new cover letter.

A summary of the relevant survey responses is presented in Table 1. A majority of the respondents were over 50 years of age with almost 20% above 70. While level of education was roughly equivalent for males and females, females were more likely to have pursued education beyond a college degree. Farmers' markets were the most commonly used market outlet for vendors in 2004. Attendance at farmers' markets varied from one to ten different markets, with an average number of 1.6 markets. The average vendor attended a market at least 2 days of the week during the peak season of 2004. The most frequently reported distance traveled to sell at a farmers' market was 10–19 miles, although 6% traveled 50 miles or more, and 18% sold in states bordering West Virginia. The median range of farmers' market sales reported for 2004 was $1500 to $2999.

Table 1. Descriptive statistics from survey.

Vendor characteristics	% of survey respondents
Age >50 years	63
Male	58
High School diploma	32
College, graduate or doctoral degree	31
Resident of West Virginia	82
Promotional method: free samples	39
Promotional method: bulk discounts	34
Advertising: business cards	34
Pricing: comparison with other vendors	57
Pricing: production cost plus profit margin	33
FMNP[1] vouchers ⩽20% of total farmers' market sales	65
Total farmers market sales ⩽$1499 for 2004 season	41
⩽10% of total farm income from farmers' market sales	25
91–100% of total farm income from farmers' market sales	14
Farmers market sales ⩽10% of total household income	53
Somewhat satisfied with profit margins	50
Farmers market production/marketing work hours per week ⩾50	29
Off-farm employment: ⩾40 hours per week	16
Off-farm employment: none	59

[1] The Women, Infants and Children (WIC) Farmers' Market Nutrition Program (FMNP) and the Senior Farmers' Market Nutrition Program are US Department of Agriculture programs which provide vouchers to WIC recipients and low-income seniors that can be exchanged for fresh, locally grown fruits and vegetables at farmers' markets. Vouchers from either program are included when referring to the FMNP.

Research Methods

To understand factors that impact the level of total farmers' market sales, the percentage of household income from farmers' markets and the amount of household income from farmers' markets, three linear regression equations were estimated using ordinary least squares (OLS) with the above three financial measures as dependent variables.

Initial examination of the data along with WVU Extension Service knowledge of market vendor demographics

Table 2. Farmers' market vendor groups.

Defining characteristic	Retired vendor	Part-time producer	Full-time farmer with no off-farm	Full-time farmer with off-farm
Age	⩾60	<60	<60	<60
Number of hours/week worked at farmers' market operation	Any amount	<30	⩾30	⩾30
Number of hours per week worked off farm	<10	Any amount	<10	⩾10
% female	24	44	24	9
% of respondents ($N = 176$)	31	29	22	18
Chi-squared results				
Total farmers' market sales in 2004	<$4500	<$3000	⩾$4500	⩾$4500
% total household income from farmers' market sales	⩽10%	⩽10%	>10%	>10%

indicated that there may be several distinct groups of farmers' market vendors. To analyze this issue, vendors were divided into four categories using the defining characteristics presented in Table 2. Chi-squared tests were then used to determine whether these were significantly different groups with respect to total farmers' market sales and percentage of household income from farmers' markets (results in Table 2). The retired vendors and part-time producers were not significantly different from each other; neither were the two groups of full-time farmers. Part-time producers were distinct when compared to both groups of full-time farmers (statistically significant at the 0.01 level). Retired vendors were significantly different from full-time producers with no off-farm job when considering total farmers' market sales and percentage of household income from farmers' markets (at the 0.01 level). In addition, retired vendors were distinct from full-time producers with an off-farm job with respect to total farmers' market sales (at the 0.01 level) and percentage of household income from farmers' markets (at the 0.05 level). Consequently, for the OLS estimation, retired vendors and part-time producers were combined into one group, which was used as an explanatory variable, as were the full-time farmers both with and without off-farm jobs.

There was some variation with respect to gender between these different vendor groups (Table 2). Chi-squared tests that examined differences between male and female farmers' market vendors with respect to total farmers' market sales and percentage of household income from farmers' market sales found no statistically significant difference between the genders, so gender was not used as an explanatory variable in the econometric equations.

Variables used in the three OLS models are listed in Tables 3 and 4 along with their definitions. Descriptive statistics for the variables are given in Tables 5 and 6. All models were estimated using LIMDEP software and were corrected for heteroskedasticity[32].

Results and Discussion

Results of the econometric estimations are presented in Tables 7–9 for the total farmers' market sales, percentage of household income from farmers' market sales models and household income from farmers' market sales, respectively. Those variables which were not statistically significant are not presented in the tables due to space constraints. For all of the models, the number of farmers' markets attended was not statistically significant. Surprisingly, products labeled 'organic' did not increase total farmers' market sales, household income from farmers' markets or percentage of household income from farmers' markets, as this variable was not significant in any of the models. Three promotional strategies—bulk discounts, free samples and various others—were not significant in any of the models. For both the total farmers' market sales model and household income from farmers' markets model, none of the different types of products produced were significant. The number of different types of market outlets used was not significant in the household income from farmers' markets model or the percentage of household income from farmers' markets model.

It is not surprising that the number of days per week and the number of weeks throughout the season during which a vendor sells at farmers' markets are both statistically significant in all of the models. If a producer increased the average days per week he/she sold at a farmers' market by one, total farmers' market sales over the season would increase by $2681, annual household income from farmers' markets would increase by $2363 and the percentage of household income from farmers' markets would increase by 5.4 (for example, 10% of household income from farmers' markets would become 15.4%). This is in keeping with Payne's findings that, nationwide, markets which generated annual sales greater than $500,000 were open 3.1 days per week, as opposed to 1.8 days per week for markets that generated sales less than $500,000[10]. Increasing the number of weeks of the season by one has a smaller impact: $448 for total farmers' market sales and $378 for annual household income from farmers' markets, and the percentage of household income from farmers' markets would increase by only 0.7. Similarly, markets nationwide were much more likely to be in a higher sales category if they were open for 20 or more weeks of the year[10].

Table 3. Variables used in models.

Variable	Description (all for 2004)
TFMSALES[1]	Total sales at farmers' markets in West Virginia (US dollars)
PHHIFM[2]	Percentage of household income from farmers' market sales
INCFM[3]	Amount of household income from farmers' markets (US dollars)
NUMMO	Number of market outlets used
NUMFM	Number of different farmers' markets participated in
NUMDAYS	Number of days per week vendor sold at farmers' markets (peak season)
NUMWKS	Number of weeks vendor sold products at farmers' markets
MKTOSWV	Sold at farmers' market outside West Virginia (yes = 1)
DISMKT	One way mileage to attend main farmers' market
PFMNP	Percentage of total farmers' market sales from FMNP vouchers
ORGANIC	Label product as organic, biodynamic, or chemical/pesticide-free (yes = 1)
NUMPROD	Number of different products produced for sale at farmers' markets
COSTPLUS	Established product prices using cost of production plus profit margin (yes = 1)
SATFM[4]	Level of satisfaction with profits from farmers' market sales (4-point Likert scale)
EDUC	Highest level of education completed by vendor (4 possible levels)
LIMRES	Limited-resource farmer[34] (annual household income less than $20,000) (yes = 1)
FTFM	Full-time farmer, with or without off-farm job (yes = 1)
RETPT	Retired vendor or part-time farmer (yes = 1)

[1] Twenty-one ranges of total sales from farmers' markets in 2004 were presented in the questionnaire. The midpoint of each of these ranges was used as the total farmers' market sales dependent variable.
[2] Ten ranges were available for percentage of total household income from farmers' markets. The midpoint of each of these ranges was used as the dependent variable.
[3] Total household income from farmers' markets in 2004 was calculated by multiplying the percentage of household income from farmers' markets with the midpoint of one of the 21 ranges chosen by the respondent when reporting total household income for 2004.
[4] The 4-point Likert scale for this survey question went from 1 for very satisfied to 4 for very unsatisfied.

Table 4. Promotional strategy, information method and type of product variables used.

Promotional strategies used when selling at farmers' markets (yes = 1)	
BUY1GET1	Buy a certain number, get one free
BULK	Bulk discounts
BARGAIN	Bargaining over price
SAMPLE	Free samples/tastings
SECONDS	Seconds or canning quality at a reduced price
COMBOPKG	Combination of products into a 'package'
OTHERP	Other promotional strategies
Methods used to give information to customers (yes = 1)	
LISTS[1]	Newsletter mailing list and/or email list
PRINT[1]	Photos of farm or facility, brochures, business cards
OTHERI[1]	Recipe cards, website, other information methods
Types of products produced for sale at farmers' markets (yes = 1)	
HASVEG	Vegetables
HASDEM	Dairy, eggs and/or meat
HASLP	Live plants
HASFN	Fruits and/or nuts
HASHF	Herbs and/or flowers
HASPP	Processed products

[1] Can be greater than one: LISTS includes two methods; PRINT and OTHERI each include three.

Total farmers' market sales

Vendors who sold outside of West Virginia had higher average annual farmers' market sales by $2811. It is unclear to what degree this is due to differentials in population density, standard of living or education levels between metro areas outside West Virginia and lower-income rural areas within the state. Similar results were found in California where estimated gross sales in metro areas were higher than in small towns, where they were higher than in rural markets[27]. Total farmers' market sales in 2004 for limited-resource farmers were lower by $3909. Further research into why these farms have lower sales is needed, especially if these farmers are using their limited off-farm income to support their farming operation, as one study of Virginia producers found[33]. Full-time farmer status did not significantly impact total farmers' market sales nor did the percentage of sales from the FMNP. Cost-plus pricing increases annual total farmers' market sales by $2116, meaning farmers are not only covering their costs of production but are also increasing sales by using this method. This evidence should encourage farmers to keep accurate records of their costs and then allow an adequate profit margin when setting prices.

Using print media to provide information to customers increases sales by $1231, while the other methods had no impact (coefficients were not statistically significant). Customers apparently still prefer a familiar method of information provision, which they can retain for reference. Bargaining, when used as a promotional strategy, increases annual farmers' market sales by $2773. Bargaining likely increases the volume sold and, in addition, should satisfy the producer and the consumer by allowing both to agree upon a mutually acceptable price. Two promotional strategies were found to decrease total yearly farmers' market sales: selling 'seconds or canning quality at a reduced rate', which decreases sales by $1771, and selling 'combinations of products in a package', which decreases sales by $4173. While the drop in total sales from selling seconds is not surprising due to the lower

Table 5. Descriptive statistics for variables used in models.

Variable	Mean	Std. dev.	Minimum	Maximum
Total farmers' market sales	7423.66	9756.38	749.50	30,749.50
Household income from farmers' markets	7087.49	10,566.83	125.00	74,012.02
% household income from farmers' market	18.69	23.45	5.50	95.50
Number of market outlets used	1.83	0.91	1.00	4.00
Number of farmers' markets	1.68	1.28	1.00	10.00
Days per week at farmers' market	2.47	1.80	1.00	7.00
Weeks at farmers' markets	13.13	6.37	2.50	22.50
Farmers' markets outside West Virginia	0.18	0.39	0.00	1.00
Number of miles from main market	19.53	14.17	4.50	54.50
Percent of market sales from FMNP vouchers	23.01	20.31	10.50	90.50
Products labeled 'organic' (yes = 1)	0.19	0.39	0.00	1.00
Number of products produced	10.37	7.31	0.00	34.00
Prices set at cost plus profit margin (yes = 1)	0.34	0.47	0.00	1.00
Satisfaction with farmers' market profit	2.98	0.87	1.00	4.00
Vendor education level	1.98	1.08	1.00	4.00
Limited-resource farmer (yes = 1)	0.30	0.46	0.00	1.00
Full-time farmer (yes = 1)	0.40	0.49	0.00	1.00
Retired or part-time farmer (yes = 1)	0.60	0.49	0.00	1.00

Table 6. Descriptive statistics for variables used in models (continued).

Variable	Mean	Std. dev.	Minimum	Maximum
Buy a certain number, get one free	0.17	0.38	0.00	1.00
Bulk discounts	0.35	0.48	0.00	1.00
Bargaining over price	0.19	0.39	0.00	1.00
Free samples	0.40	0.49	0.00	1.00
Seconds/canning quality at reduced rate	0.26	0.44	0.00	1.00
Products combined into a package	0.12	0.32	0.00	1.00
Other promotional strategies	0.20	0.40	0.00	1.00
Newsletter or email list	0.08	0.35	0.00	2.00
Photos, brochures or business cards	0.62	0.74	0.00	3.00
Recipes, Web site or other informational method	0.52	0.62	0.00	3.00
Vegetables	0.79	0.41	0.00	1.00
Dairy, eggs and/or meat	0.20	0.51	0.00	1.00
Live plants	0.29	0.45	0.00	1.00
Fruits and/or nuts	0.36	0.48	0.00	1.00
Herbs and/or flowers	0.25	0.43	0.00	1.00
Processed products	0.27	0.45	0.00	1.00

sales price, selling combination packages (which are essentially 'value-added' products) was expected to increase sales. This unexpected result may imply that 'packages' also applied to sales of one product by volume (quart, pint, peck, etc.) or by the bunch as opposed to sales by weight, and prices by volume were relatively lower than prices by weight.

Percentage of household income from farmers' markets

Retired or part-time producers receive a 6.1 lower percentage of their household income from farmers' markets. This is not surprising as these vendors are more likely to have other sources of income such as a pension or off-farm job. As a vendor's level of education increases, his/her percentage of household income from farmers' markets decreases. For example, if a vendor with only a college degree obtains a master's or doctoral degree, the percentage of household income from farmers' markets would be lower by 2.7. This is a reflection of the higher earning power in an off-farm job for those with higher education, resulting in a decrease in importance of farmers' market income.

The percentage of household income from farmers' markets decreases by 9.7 when using the combination package promotional strategy and by 6.4 when selling seconds or canning quality at a lower price. This is not surprising as both of these methods also reduced total farmers' market sales. Neither bargaining over price nor

Table 7. Total farmers' market sales model results.

Variable	Coefficient	Standard error	*t*-statistic	*P*-value
Constant	−5181	1699.4	−3.05	0.003
Days per week at market	2681	366.4	7.32	0.000
Weeks at farmers' markets	448	77.5	5.78	0.000
Bargaining over price	2773	1127.4	2.46	0.015
Seconds/canning quality at reduced rate	−1771	1055.0	−1.68	0.096
Products combined into a package	−4173	1620.4	−2.58	0.011
Photos, brochures, or business cards	1231	586.6	2.10	0.038
Prices set at cost plus profit margin	2116	1244.8	1.70	0.092
Markets outside West Virginia	2811	1502.2	1.87	0.064
Limited-resource farmer	−3909	1013.3	−3.86	0.000
Adjusted $R^2 = 0.70911$				

All significant at $P \leqslant 10\%$ (115 d.f.).

Table 8. Percentage of household income from farmers' market sales model results.

Variable	Coefficient	Standard error	*t*-statistic	*P*-value
Days per week at market	5.4	1.2	4.42	0.000
Number of weeks at market	0.7	0.2	3.20	0.002
Seconds/canning quality at reduced rate	−6.4	3.4	−1.89	0.060
Products combined into a package	−9.7	4.0	−2.43	0.016
Prices set at cost plus profit margin	6.7	3.1	2.13	0.035
Vendor education level	−2.7	1.3	−2.11	0.037
Retired or part-time farmer	−6.1	3.1	−1.98	0.050
Number of products produced	0.5	0.2	2.14	0.034
Adjusted $R^2 = 0.39248$				

All significant at $P \leqslant 10\%$ (138 d.f.).

Table 9. Household income from farmers' market sales model results.

Variable	Coefficient	Standard error	*t*-statistic	*P*-value
Days per week at market	2363	732.5	3.23	0.002
Number of weeks at market	378	118.1	3.20	0.002
Miles from main market	107	49.6	2.17	0.032
Buy a certain number, get one free	−2984	1560.2	−1.91	0.058
Products combined into a package	−5712	2114.4	−2.70	0.008
Photos/brochures/business cards	1796	996.2	1.80	0.074
Satisfaction with market profit	−1742	789.4	−2.21	0.029
Retired or part-time farmer	−2748	1606.8	−1.71	0.090
Adjusted $R^2 = 0.42243$				

All significant at $P \leqslant 10\%$ (110 d.f.).

buy-one-get-one-free strategies affected the percentage of household income obtained from farmers' markets. None of the methods used to provide information to customers were significant. Using cost-plus pricing increases the percentage of household income from farmers' markets by 6.7, as it also increased total farmers' market sales. Adding one more product to the mix available for sale at the market increases by 0.5 the percentage of household income from farmers' markets. This is consistent with a previous study of West Virginia consumers which found that limited volume and variety were more significant issues than prices in deciding whether or not to patronize farmers' markets[14]. Product diversity may thus be a good indicator of the degree to which producers can rely on market sales for income. Although, as expected, when satisfaction with farmers' markets profits increased, so did the percentage of

household income derived from farmers' markets, this variable was not statistically significant.

Amount of household income from farmers' markets

Household income from farmers' market sales was positively influenced by the distance the vendor traveled to market his/her products. A 1 mile increase in distance traveled would increase annual household income from farmers' markets by $107. This is most likely a reflection of the distance that some vendors travel to reach more urban markets, which typically have higher prices and more customers. Govindasamy et al.[28] found that farmers selling in urban or suburban areas were more likely to have higher farm income.

Using print informational methods increases household income from farmers' markets by $1796, as it also increased total farmers' market sales. Selling combination packages decreases household income by $5712. In addition, using the 'buy a certain number, get one free' promotional strategy decreases annual household income from farmers' markets by $2984. This latter effect may be due to a decline in the number of customers who preferentially buy in bulk, making the promotional offer appealing to a limited number of shoppers[29]. Bargaining over price and selling seconds at a reduced rate did not have a significant impact on household income, and neither did using cost-plus pricing.

In regard to employment status, vendors who were retired or only worked part time at their farmers' market operation had lower household income from farmers' markets by $2748. Not surprisingly, as education level increases, the amount of household income from farmers' markets decreases; this variable was not significant, however. A one point increase in the level of satisfaction with farmers' market profit margins increases the amount of household income generated from farmers' market sales by $1742. This is not surprising, as farmers who are satisfied with the profitability of their farmers' market outlets may be more likely to emphasize it in their marketing strategy and consequently rely on it as an important income source.

Limitations

This paper addresses farmers' market vendors, providing a limited look at factors impacting the supply side of the market while not including important aspects of the demand side. Future research plans include a survey of farmers' market customers in West Virginia, which should provide a more complete picture. In addition, characteristics of the markets themselves are not included. Factors such as market location, organizational structure, and age of the market might all influence vendors' total sales[27]. For farmers who sold at more than one market, we do not know which market was more important for sales or income. It would also be useful to have relevant information from farmers who directly market their products but do not use farmers' markets; however, this survey was only of farmers' market vendors. Due to reluctance of survey respondents to provide detailed data on farm sales and household income, dependent variables are not the exact amounts earned but instead had to be created from ranges. Although we do know whether farmers sold at farmers' markets outside of West Virginia, we do not know where those markets are or how important sales at those outside markets were to farm or household income. Future research into the spatial relationships between farm location, markets and customers could provide valuable insight. In addition, results from this study are for a relatively rural state and may not apply to urban areas.

Conclusion

A 2004–2005 survey of West Virginia farmers' market vendors found that retired and part-time vendors were significantly different from full-time producers, both with and without off-farm jobs. Full-time producers, not surprisingly, were more likely to have higher total farmers' market sales as well as earning a higher percentage of annual household income from farmers' markets. Econometric estimation was used to analyze the factors that impact total farmers' market sales in addition to the amount and percentage of household income from farmers' markets.

Given the results, vendors, market managers and Extension educators can target as priorities the specific practices that are shown to increase sales levels. With a better understanding of vendor demographics and the degree to which part-time, retired and full-time vendors rely on markets for income, markets and educators may more appropriately tailor tools for vendor recruitment and outreach. Limited-resource producers with a higher reliance on market sales for income may have unique educational needs relative to part-time or 'hobby' farmers. For vendors hoping to obtain a greater percentage of their household income from farmers' markets, selling more days of the week, more weeks of the year and more products overall may be a good start.

For many of West Virginia's diverse small farms, farmers' markets represent an essential outlet for the direct marketing of diverse agricultural products. Due to the seasonality and relative unpredictability inherent in farming, producers should benefit from research-based predictors of sales and market income. These results allow us to conclude that an extended farmers' market season as well as product diversity allow vendors to increase sales and the degree to which they can rely on markets for income. In addition, offering printed materials to customers is more effective than offering discounts for seconds/canning quality or combining products into a package. While bargaining may increase total market sales, it appears that strategic 'cost-plus' pricing is even more effective at increasing the amount and percentage of household income from farmers' markets. Such information

should prove useful for vendors, market managers and educators, as communities nationwide seek to develop and improve upon viable direct-marketing alternatives to cultivate sustainable local food systems.

Acknowledgements. We would like to thank Alan Collins of WVU for his valuable suggestions, the USDA Northeast Sustainable Agriculture Research and Education Program (SARE) for its financial support of this project, and most importantly, the many vendors who generously shared their time and insight by completing the survey.

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Renewable Agriculture and Food Systems: 22(1); 30–40 doi:10.1017/S1742170507001573

Six-year comparison between organic, IPM and conventional cotton production systems in the Northern San Joaquin Valley, California

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Accepted 6 March 2006 **Research Paper**

Abstract

Three different cotton production strategies [certified organic, conventionally grown, and reduced insecticide input/integrated pest management (IPM)] were compared in field-sized replicates in the Northern San Joaquin Valley (NSJV), California, from 1996 to 2001. We measured arthropod abundance, plant development, plant density, pesticide use, cost of production, lint quality and yields in the three treatments. Overall pest abundance was low, and a key cotton fruit pest, *Lygus hesperus* Knight, known as the western tarnished plant bug (WTPB), did not exceed action thresholds in any treatment. Organic fields had significantly more generalist insect predators than conventional fields during at least one seasonal interval in all but one year. While there were no significant differences in plant development, plant densities at harvest were lower in organic than conventional and IPM fields. Some measures of lint quality (color grade and bale leaf rating) were also lower in the organic treatment than in either the IPM or the conventional treatments. Synthetic insecticides, not allowed for use in organic production, were also used in significantly lower quantities in the IPM fields than in the conventional fields. Over the 6-year period of the study, IPM fields averaged 0.63 kg of active ingredient (AI) insecticide per hectare, as opposed to 1.02 kg AI ha^{-1} for conventional fields, a reduction of 38%. Costs of production per bale were on average 37% higher for organic than for conventional cotton. This cost differential was primarily due to greater hand-weeding costs and significantly lower yields in organic cotton, compared with either IPM or conventional cotton. Average 6-year yields were 4.4, 5.4 and 6.7 bales ha^{-1} for organic, IPM and conventional treatments, respectively. Low world cotton prices and the lack of premium prices for organic cotton are the primary obstacles for continued production in the NSJV.

Key words: California cotton, organic cotton, integrated pest management, pesticide use reduction

Introduction

California's upland cotton production ranks third in the nation, generating about 10% of the United States' total[1]. Over the period 1996–2001, there were between 300,000 and 400,000 hectares of planted upland cotton in the state[1]. Over the period of 1999–2001, there were between 365 and 486 hectares of certified organic upland cotton, comprising less than 1% of the state's total[2]. Cotton is historically one of the top contributors to total farm income in California. From 1996 to 2001, the total value of the California cotton crop ranged from $918 million to $356 million, respectively[3].

Cotton is also one of the largest users of agricultural chemicals of any commodity produced in California. In 2001, cotton growers applied 5.5% of all pesticides reported used in the state[4]. During this time, an average of over 10 kg of pesticide active ingredient (AI) was applied per hectare in California cotton[4].

From 1994 through 1995, we compared organic and conventional cotton production in the Northern San Joaquin Valley (NSJV)[5,6]. During that project, we found that cotton growers were very interested in the potential environmental and economic benefits of pesticide use reduction strategies and organic cotton production. A study was initiated that compared three production systems: reduced insecticide input/integrated pest management (IPM), certified organic and conventionally managed cotton. Four key questions were addressed: (1) Would the reduction and/or elimination of insecticides impact pest and beneficial insect abundance?

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Table 1. Grower information and fields monitored from 1996 to 2001.

Treatment	Year	No. of growers	No. of fields monitored	Total hectares monitored	Total cotton hectares	Mean hectares per grower
Conventional	1996	3	5	65	577	192
	1997	4	11	210	669	167
	1998	3	9	164	428	143
	1999	5	8	199	583	117
	2000	6	8	164	1354	226
	2001	4	8	194	1608	402
IPM	1996	4	4	124	329	82
	1997	4	4	49	340	85
	1998	2	3	43	67	34
	1999	3	4	63	91	30
	2000	7	7	124	212	30
	2001	8	8	142	243	30
Organic	1996	2	5	115	352	176
	1997	3	6	111	343	114
	1998	1	5	118	253	253
	1999	2	8	183	277	138
	2000	2	8	212	233	117
	2001	2	8	220	241	121

(2) Would the cost structure of each management strategy vary, and if so, how? (3) Would harvest parameters, such as lint quality and yield, differ based on management strategy? (4) Would organically grown cotton be viable and competitive with other local management strategies?

Methods and Materials

Plot selection and management

In April of each year from 1996 to 2001, fields were selected and designated as one of three treatments: organic, IPM and conventional (Table 1). Organically managed fields were registered with the California Department of Food and Agriculture Organic Program, certified according to the California Organic Foods Act (COFA) of 1990, and inspected by a third party (Quality Assurance International, Inc.). Fields designated as organic or IPM were managed by growers in the BASIC (Biological Agriculture Systems in Cotton) program. This grower-initiated program encouraged enrolled growers to plant their cotton early (in April), and near alfalfa fields for pest and beneficial insect attraction[7]. Growers in this program received weekly monitoring reports from the authors and BASIC personnel for insecticide use decision-making. These growers also received periodic early season releases of insectary-reared green lacewing (*Chrysoperla carnea*) larvae, at an average of 12,000 larvae per hectare, for management of spider mites and aphids. Reductions of calendar-based insecticide applications were also encouraged in IPM fields. Conventional fields were managed outside of the BASIC program.

Fields were chosen based on geographic location (within an 8 km radius of Chowchilla, California), size (8–32 hectares) and planting date (mid-April to early May). Cotton plant variety was also used to select fields; San Joaquin Acala variety Maxxa was used exclusively in organic fields, and was used predominately in IPM and conventionally managed replicates from 1996 to 1999. Beginning in 2000, the genetically modified (Roundup Ready™) Riata variety of the Maxxa breeding line was used in nearly all IPM and conventional fields. Differences in specific production practices among each of the treatments are shown in Table 2.

Arthropod pests and natural enemies

Both-sweep net samples and visual leaf counts were made for determination of arthropod abundance. Sampling was conducted weekly from June to September, during which time three distinct intervals of the production season were established: early (June), mid (July) and late (August–September). Fields were divided into four quadrants and samples of 50 sweeps were taken from each quadrant with a 38 cm canvas insect net. Each sample was taken from one randomly chosen row, and field edges (the outer ~15 m of each field) were avoided. This procedure was used to collect the western tarnished plant bug (WTPB), also known as the lygus bug (*Lygus hesperus* Knight), which is a key cotton fruit pest, and generalist predators *Orius tristicolor* (minute pirate bug), *Geocoris* spp. (big-eyed bug), *Nabis* sp. (damsel bug), *Zelus* sp. (assassin bug) and *Chrysoperla* spp. (green lacewing). Insect abundances were recorded in the field using a small tape recorder. These records were later transcribed in the laboratory for entry into a database.

Visual leaf counts were conducted by weekly examination of the eighth main stem leaf from the plant apex. Five plants were chosen randomly from each of the four

Table 2. Summary of production practices and inputs 1996–2001.

Activity	Type of input/practice	Input/practice	Organic	IPM	Conventional
Pre-harvest	Cotton seed	Fungicide treated	x	x	x
		GMO Roundup Ready		x	x
	Fertilizer	Composted manure	x	x	
		Chemical fertilizers		x	x
	Weed control	Mechanical cultivation	x	x	x
		Hand-weeding crews	x	x	x
		Uncap beds			x
		Preplant chemical herbicides		x	x
		In-season chemical herbicides		x	x
	Insect control	Natural enemy releases	x	x	
		Sulfur	x	x	x
		Chemical insecticides		x	x
		Chemical miticides		x	x
	Irrigation	Alternate rows during season	x		
		Every row all season	x	x	x
Harvest	Crop preparation	Organic acids	x		
		Chemical growth regulators		x	x
	Assessments	Classing	x	x	x
		Research, certification	x	x	x

quadrants to give a total of 20 leaves sampled per field. Spider mites (*Tetranychus* spp.) and cotton aphids (*Aphis gossypii*) were recorded using presence/absence counts. Generalist predators such as minute pirate bugs, big-eyed bugs (eggs and nymphs), green lacewings (eggs and larvae) and western predatory mite (*Metaseiulus occidentalis*) were also counted in these leaf samples.

Plant development parameters

Plant development parameters were measured weekly from June to September. Five plants were chosen randomly and removed from each of the four quadrants, for a total of 20 plants per field on each sampling occasion. The architecture of these plants was mapped using guidelines from the University of California[8], which were developed to help predict yields, measure plant stress and insect damage, and time growth regulator and defoliant applications. Parameters measured included retention of first position bolls (the highest yielding position) and the number of bolls in the bottom five fruiting positions (a measure of loss due to insect damage or other stress). Total bolls per plant were also measured immediately prior to harvest.

Plant density

Shortly after cotton plant emergence in each sample year, we determined the average plant density (plants per hectare) in each field. From each of the four quadrants, we counted and averaged the number of plants in four randomly selected 1/2470 ha linear row samples. This average was then multiplied by 2470 to determine the number of plants per hectare. Plant density was again determined at harvest each year.

Pesticides

The type, quantity and frequency of pesticide applications were recorded for each field treatment through grower interviews conducted after harvest each season, from 1997 to 2001. Pesticide quantities were converted into kilograms of AI per hectare based on manufacturer's label rates. Pesticides were classified as insecticides, miticides, herbicides, crop preparation growth regulators and defoliants.

Cost of production

Production costs were also obtained through post-harvest grower interviews in December to January of each following production year, excluding 1998. An average budget was then made for each treatment following the methods established by Klonsky et al.[9]. Costs were divided into pre-harvest- and harvest-related categories. Included within each category grouping were labor (tractor operator hours, hand weeding), field power (ripping, leveling, disking, bedding, ditching and cultivating), materials (compost, water, seed, pesticides and lacewings) and custom/rentals (i.e., custom applications of compost or aerial spraying and harvest machinery rentals). Both total costs per hectare and cost per bale were calculated. When not directly provided by the grower, costs of individual operations were based on values presented by Klonsky et al.[9].

Cotton lint quality

Gin records were used to measure lint quality, an important determinant of lint price. Lint quality consists of several parameters, the most important of which are fiber length, fiber strength, fiber micronaire (diameter), color grade (a measure of lint staining caused by foreign material in the harvest) and bale leaf ratings (leaf contamination in harvested lint). We combined color grades into three groups, for ease of analysis. Grades 11, 21 and 31 generally receive the highest price, and were combined into the highest quality group. Groups two (grades 41, 51 and 61) and three (other) were lower quality lint. We obtained all gin records except for those from the organic fields in 1999, which were lost during a gin consolidation.

Cotton lint yield

Average lint yield (bales per hectare) per treatment was determined by using gin records obtained either from gin operators or during post-harvest interviews with participating growers.

Statistical analysis

Data taken throughout the production season, which included arthropod pests and natural enemies, plant development parameters and plant density, were analyzed using repeated measures analysis of variance (multivariate analysis of variance, MANOVA). Values were averaged by 2-week periods to address missing data. Values for missing data points were estimated by running a full analysis of variance (ANOVA) model with the data; the predicted values were then used in place of the missing ones. Tukey's Studentized Range (honestly significant difference, HSD) Test was then used for all *post hoc* comparisons, including growers' overall pesticide use, annual production costs per hectare and costs per bale, and yields. Lint quality differences were determined by single factor ANOVA (F ratio) tests. Analyses for plant development parameters, planting densities, lint quality (except for color grades) and yields were done using SAS Version 8.02 for Windows[10]. Analyses for insect abundance, pesticide use, costs of production and lint color grades were done using SPSS Version 11.5[11].

Results and Discussion

Arthropod pests and natural enemies

The only significant difference between treatments for total WTPB abundance (adults plus nymphs) was during the mid-season interval of 1998, when there were more total WTPB in organic than in conventional fields ($P<0.05$). Six-year average WTPB abundance was relatively low with reference to action thresholds, with mid-season averages of 2.83 ± 0.85, 2.61 ± 0.70 and 2.41 ± 0.60 WTPB per sweep net sample, in organic, IPM and conventional treatments, respectively. These values were well below the suggested mid-season action threshold of 7–10 WTPB per sweep net sample[12].

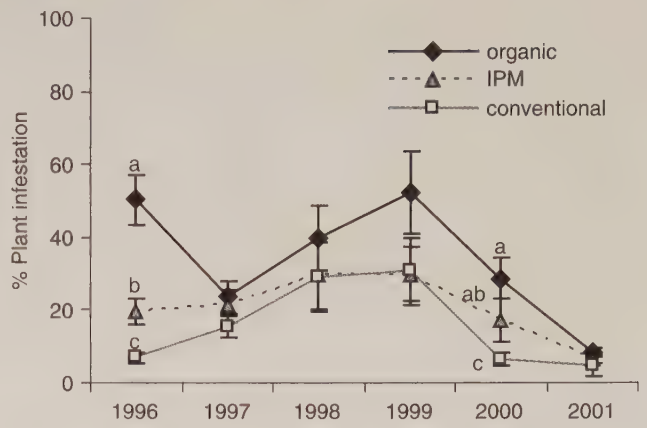

Figure 1. Average percentage mite infestation from 'early' season (June). Percentages based on mite presence/absence counts on cotton plants. Different letters within years represent statistical differences between treatments (ANOVA; $P<0.05$).

Significant differences in WTPB nymphal abundance between treatments were more frequent. Organic fields had more WTPB nymphs than did either IPM or conventional fields in the late season interval of 1996 and more than IPM fields in the early season interval of 2000 ($P<0.05$). Organic fields had significantly fewer WTPB nymphs than did IPM or conventional fields in the late season interval of 2000, and also fewer than conventional fields in the mid-season interval of 2001 ($P<0.05$). Again, 6-year WTPB abundance was relatively low, with mid-season nymph averages of 1.00 ± 0.96, 0.86 ± 0.81 and 0.64 ± 0.29 bugs per sweep net sample, for organic, IPM and conventional treatments, respectively.

There were no consistent differences in WTPB abundance, between any treatments. During this study, WTPB did not reach pest status in any treatment in the NSJV. This result could be due to the admixture of alfalfa fields (a preferred host) in this area of cotton production[7,13–15].

Mean percentage mite infestation was significantly greater in organic fields than in conventional fields during the early season intervals of 1996 and 2000, and greater than IPM fields in the early season interval of 1996 (Fig. 1). In 1996 and 1999, mite infestation in organic fields slightly exceeded 50%, the upper end of the action threshold[12]. Such infestations can impact subsequent yields[8], and occurred in spite of sulfur use by organic growers (see pesticides below). A typical whole field application of sulfur for mite control was made at the label rate of $34\,kg\,ha^{-1}$. However, in this study, organic growers more frequently applied 0.9–1.4 kg of dusting sulfur on field margins only. Sulfur use in organic fields ($11.8\,kg\,ha^{-1}$) constituted the largest pesticide input recorded in any treatment. Beginning in 2000, organic and IPM growers lowered mite infestation levels by better utilizing monitoring information, which enabled them to apply timelier synthetic miticide or sulfur treatments.

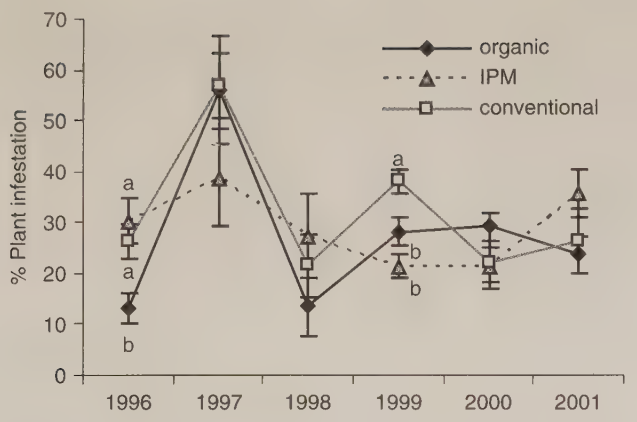

Figure 2. Average percentage aphid infestation from late season (August–September). Percentages based on aphid presence/absence counts on cotton plants. Different letters within years represent statistical differences between treatments (ANOVA; $P < 0.05$).

Percentage cotton aphid infestation was significantly greater in conventional fields than in organic fields during the late season interval of 1996, and greater than both organic and IPM fields during the late season interval of 1999 (Fig. 2). The lack of early or mid-season insecticide stress in organic cotton may have favored naturally occurring biological control of cotton aphid[16]. High levels of late season cotton aphid infestation can cause aphid honeydew accumulation on open bolls, resulting in sticky cotton lint. This is problematic during harvest and ginning, and can also lead to fungal growth, which can stain the cotton fibers. No sticky cotton was reported in gin records in any year of the study, which suggests aphid pressure remained below economic thresholds.

Total generalist predator abundance (adults plus nymphs) was significantly greater in organic fields than in either conventional or IPM fields, during ten and four different seasonal intervals, respectively (Table 3). IPM fields also had greater total predator abundances than did conventional fields during the mid-seasonal intervals of 1997 and 1998.

Nymphal natural enemies were significantly more numerous in organic fields than in conventional or IPM fields during seven and three different seasonal intervals, respectively (Table 4). IPM fields also had greater abundances of predator nymphs than did conventional fields during the mid- and late seasonal intervals of 1996.

Generalist predator density on cotton leaves was significantly greater in organic fields compared with conventional fields in the early and mid-season intervals of 1996, and the mid-season interval of 1999 ($P < 0.05$). These predators in organic fields were also more abundant than those in IPM fields during the mid-seasons of 1996, 1999 and 2001, and the late season of 2001 ($P < 0.05$). Six-year average leaf-sampled predator densities were 0.22 ± 0.04, 0.16 ± 0.02 and 0.12 ± 0.02 per leaf, for organic, IPM and conventional treatments, respectively.

Organic fields had significantly more total natural enemies, nymphal natural enemies and leaf-sampled predators than did conventional fields in 56% (10/18 sampled months), 39% (7/18 sampled months) and 17% (3/18 sampled months) of recorded seasonal intervals. This

Table 3. Average total natural enemy abundance (± SEM) by season (1996–2001).

		Treatment		
	Season	**Conventional**	**IPM**	**Organic**
1996	Early	2.42 (0.31)^{a}	2.43 (0.47)^{a}	4.00 (0.51)^{b}
	Mid	9.45 (0.53)^{a}	10.07 (0.84)^{a}	16.53 (0.97)^{b}
	Late	12.75 (0.91)^{a}	16.15 (1.59)^{ab}	17.20 (1.05)^{b}
1997	Early	6.17 (0.72)^{a}	8.69 (1.48)^{ab}	10.93 (1.56)^{b}
	Mid	12.96 (1.78)^{a}	19.81 (3.22)^{b}	20.03 (2.49)^{b}
	Late	20.74 (2.72)^{a}	28.64 (2.90)^{ab}	36.53 (3.54)^{b}
1998	Early	3.34 (0.48)	3.50 (0.76)	4.03 (0.43)
	Mid	7.41 (0.80)^{a}	12.52 (2.84)^{b}	18.85 (1.69)^{c}
	Late	12.95 (2.16)^{a}	14.70 (2.14)^{a}	20.91 (4.26)^{b}
1999	Early	11.41 (2.45)	13.19 (4.08)	13.07 (3.86)
	Mid	12.87 (0.60)^{a}	15.16 (0.99)^{ab}	17.10 (1.14)^{b}
	Late	14.56 (1.80)	16.38 (2.89)	17.42 (3.05)
2000	Early	16.10 (2.42)	12.64 (2.64)	18.28 (2.74)
	Mid	7.73 (1.33)	9.05 (2.06)	9.51 (1.52)
	Late	12.27 (2.84)	11.86 (2.36)	12.38 (2.05)
2001	Early	7.65 (0.92)	6.15 (1.75)	8.13 (1.31)
	Mid	11.90 (1.67)	12.74 (2.18)	11.46 (1.33)
	Late	9.32 (0.62)^{a}	11.24 (0.53)^{ab}	11.58 (0.62)^{b}

Different letters within seasonal intervals represent statistical differences between treatments (ANOVA; $P < 0.05$).

Table 4. Average nymphal natural enemy abundance (± SEM) by season (1996–2001).

		Treatment		
	Season	**Conventional**	**IPM**	**Organic**
1996	Early	0.40 (0.09)	0.52 (0.21)	0.91 (0.38)
	Mid	1.93 (0.18)[a]	3.10 (0.35)[b]	4.33 (0.41)[c]
	Late	2.56 (0.68)[a]	4.56 (0.43)[b]	4.71 (0.85)[b]
1997	Early	0.87 (0.44)	1.23 (1.03)	2.06 (0.98)
	Mid	3.04 (0.71)	5.36 (1.73)	3.89 (0.68)
	Late	5.18 (1.06)[a]	9.53 (3.38)[ab]	10.34 (1.45)[b]
1998	Early	0.19 (0.16)[a]	0.25 (0.14)[ab]	0.59 (0.06)[b]
	Mid	1.01 (0.35)[a]	4.17 (1.95)[ab]	4.10 (0.96)[b]
	Late	3.04 (0.33)[a]	4.33 (0.63)[a]	7.35 (0.68)[b]
1999	Early	1.61 (0.42)	2.34 (0.93)	1.71 (0.85)
	Mid	2.40 (0.52)	3.24 (1.03)	4.30 (1.08)
	Late	4.21 (0.82)	4.30 (0.95)	5.47 (1.43)
2000	Early	3.85 (1.03)[a]	3.29 (1.09)[a]	7.24 (2.16)[b]
	Mid	2.22 (0.58)	2.50 (0.72)	2.90 (0.67)
	Late	4.23 (1.44)	3.68 (1.00)	4.13 (0.92)
2001	Early	2.19 (0.53)	1.55 (0.25)	3.25 (1.00)
	Mid	3.99 (0.77)	3.20 (1.02)	3.87 (0.89)
	Late	2.65 (0.50)	3.07 (0.75)	3.76 (0.79)

Different letters within seasonal intervals represent statistical differences between treatments (ANOVA; $P < 0.05$).

pattern of higher abundance of natural enemies in organic than in conventional cotton fields is confirmed in other organic crops grown in California, including strawberries[17] and tomatoes[18]. There was no recorded seasonal interval in which conventional fields had a significantly greater abundance of natural enemies than either organic or IPM fields.

Plant development parameters

There were no significant treatment differences between any in-season plant development parameters ($P > 0.05$). The 6-year average number of first position bolls (the highest yielding position) was 7.42 ± 0.53, 7.39 ± 0.75 and 8.18 ± 0.53 for organic, IPM and conventional treatments, respectively. The percentage boll retention at the five lowest positions (a measure of possible WTPB damage to early fruit) was 65.40 ± 6.29, 68.00 ± 3.58, and 63.80 ± 3.17 for organic, IPM and conventional treatments, respectively. The total number of bolls produced per plant at the end of each year was 7.93 ± 0.41, 6.78 ± 0.55 and 7.29 ± 0.46 for organic, IPM and conventional treatments, respectively. The lack of differences between treatments with respect to percentage retention of bolls at the bottom five positions and total bolls at harvest is reflective of the consistently low WTPB pressure that we found in all treatments.

Plant density

Organic fields had significantly fewer plants at harvest than conventionally managed fields from 1996 to 1999 (Fig. 3). Organic growers generally planted their fields at lower densities during these years, believing that lower plant densities would result in less leaf contamination and generate greater boll formation. Density differences at harvest were therefore not surprising. Organic plant densities at harvest were also significantly lower than IPM fields from 1997 to 1998. Beginning in 2000, differences in plant density were not significant between treatments, as conventional and IPM growers reduced densities to levels comparable with organic fields.

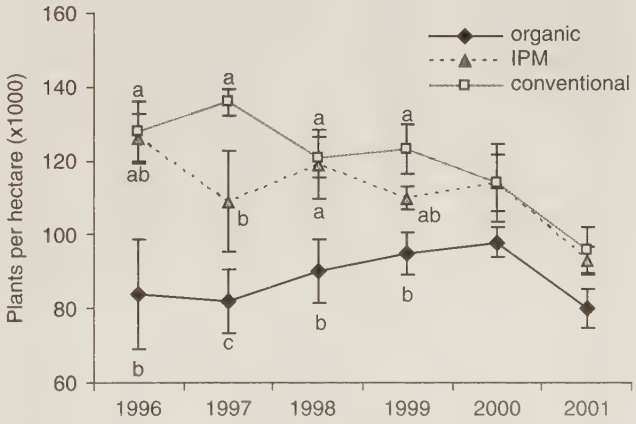

Figure 3. Average cotton plant density per hectare at harvest (1996–2001). Different letters within years represent statistical differences between treatments (ANOVA; $P < 0.05$).

Table 5. Average pesticide use (1997–2001) in kilograms of AI per hectare (± SEM).

Type of material	Material	Conventional	IPM	Organic
Synthetic insecticides	Aldicarb (Temik)	0.92 (0.16)	0.60 (0.21)	0 (0)
	Misc. lygicides	0.01 (0.01)	0.02 (0.02)	0 (0)
	Bifenthrin (Capture)	< 0.01 (< 0.01)	< 0.01 (< 0.01)	0 (0)
	Chlorpyrifos (Lorsban)	0.07 (0.03)	0 (0)	0 (0)
	Imidacloprid (Provado)	0.02 (0.02)	0.01 (< 0.01)	0 (0)
	Dimethoate (Cygon)	< 0.01 (< 0.01)	0 (0)	0 (0)
	TOTAL	1.02 (0.17)[a]	0.63 (0.21)[b]	0 (0)[c]
Synthetic miticides	Propargite (Comite)	0.07 (0.06)	0.15 (0.10)	0 (0)
	Avermectin (Zephyr)	< 0.01 (< 0.01)	0.07 (0.04)	0 (0)
	Dicofol (Kelthane)	0.13 (0.06)	0.22 (0.09)	0 (0)
	TOTAL	0.21 (0.08)[a]	0.44 (0.13)[a]	0 (0)[b]
Other miticides	Sulfur	3.07 (1.41)	0.50 (0.50)	11.79 (2.09)
Herbicides	Clethodim (Prism)	0.02 (0.01)	0.03 (0.01)	0 (0)
	Fluazifop (Fuselade)	0.03 (0.01)	0 (0)	0 (0)
	Pendimethalin (Prowl)	0.06 (0.02)	0.06 (0.03)	0 (0)
	Pyrithiobac (Staple)	0.08 (0.01)	0.18 (0.09)	0 (0)
	Glyphosate (Roundup)	0.22 (0.06)	0.12 (0.07)	0 (0)
	Trifluralin (Treflan)	0.21 (0.04)	0.48 (0.20)	0.0
	TOTAL	0.63 (0.09)[a]	0.87 (0.20)[a]	0 (0)[b]
Total synthetic pest control materials		1.85 (0.25)[ab]	1.94 (0.34)[a]	0 (0)[b]
Total pest control materials		4.92 (1.50)[ab]	2.45 (0.52)[a]	11.78 (2.09)[b]
Growth regulators	Dimethyl alkyl amine (Accelerate)	< 0.01 (< 0.01)	0.02 (0.01)	0 (0)
	Ethephon (Prep)	0.84 (0.08)	0.67 (0.17)	0 (0)
	Mepiquat chloride (Pix)	0.02 (< 0.01)	< 0.01 (< 0.01)	0 (0)
	TOTAL	0.78 (0.08)[a]	0.63 (0.16)[a]	0 (0)[b]
Defoliants	Paraquat dichloride (Starfire)	< 0.01 (< 0.01)	0.02 (0.01)	0 (0)
	Sodium chlorate (Drop, Defol 6)	1.16 (0.47)	2.04 (0.97)	0 (0)
	Thidiazuron (Ginstar)	0.10 (0.02)	0.34 (0.30)	0 (0)
	Tributyl phosphorotrithioate (Def 6)	0.29 (0.07)	0.13 (0.07)	0 (0)
	TOTAL	1.40 (0.49)[a]	2.28 (0.97)[a]	0 (0)[b]
Total synthetic crop preparation materials		2.42 (0.48)[a]	3.24 (0.94)[a]	0 (0)[b]
TOTAL PESTICIDES		7.34 (1.61)[a]	5.68 (0.88)[a]	11.79 (2.09)[a]

Different letters within categories represent statistical differences between treatments (ANOVA; $P < 0.05$).

Pesticides

Over 6 years of production, organic fields were treated with none of the synthetic pest control inputs typical of conventional and IPM fields, such as synthetic insecticides and miticides, herbicides, growth regulators and defoliants (Table 5). However, the AI weight of 'total pest control materials' and 'total pesticides' did not differ between organic and conventional treatments. This was due to the use of wettable and dusting sulfur (a miticide) in organic fields, which was the only pesticide used by organic growers. The volume of sulfur use was also responsible for organic fields accumulating higher weight of AI of 'total pest control materials' than IPM fields.

Synthetic insecticide use in IPM fields was significantly lower than in conventional fields.

Insecticide use in IPM fields averaged 0.63 kg AI ha^{-1}, as opposed to 1.02 kg AI ha^{-1} for conventional fields, a reduction of 38%. Use in all other pesticide categories was not significantly different between these two treatments.

Cost of production

Six-year average operational costs of production per bale were significantly higher for organic than for IPM or conventional fields (Table 6). These costs were 37% higher for organic than for conventional fields. The increased costs per bale were mainly due to lower yields in the organic system (see below). When calculated per hectare, costs of production were not statistically different, being only 5 and 3% higher for organic and IPM fields, when compared with conventional fields ($P > 0.05$). Operational differences included higher costs for labor (hand weeding crews and cultivation), custom applications (compost and sulfur) and harvest field power (increased harvest time and effort) in organic fields and higher materials costs (synthetic insecticides) in conventional fields. Costs of production

Table 6. Average operational production costs (± SEM) from 1996 to 2001 ($).

Activity	Input/practice	Organic	IPM	Conventional
Pre-harvest	Labor	232 (47)	143 (30)	148 (32)
	Field power	185 (22)	153 (10)	153 (12)
	Materials	383 (27)	551 (20)	667 (30)
	Custom/rentals	511 (72)	417 (32)	271 (37)
	Total cultural	1312 (74)[a]	1265 (101)[a]	1240 (122)[a]
Harvest	Labor	62 (12)	44 (5)	37 (5)
	Field power	135 (17)	86 (10)	79 (5)
	Materials	25 (10)	42 (10)	59 (22)
	Custom/rentals	15 (7)	89 (52)	64 (47)
	Total harvest	237 (27)[a]	262 (13)[a]	240 (9)[a]
Interest		69 (2)	62 (2)	62 (2)
Assessments		27 (2)	27 (2)	32 (2)
Certification fees		12 (2)	2 (2)	0 (0)
TOTAL COSTS PER HECTARE		1657 (44)[a]	1618 (64)[a]	1573 (67)[a]
YIELD (bales per hectare)		4.4 (0.2)[a]	5.4 (0.2)[b]	6.7 (0.2)[c]
TOTAL COST PER BALE		376 (19)[a]	300 (41)[b]	235 (24)[b]

Different letters within categories represent statistical differences between treatments (ANOVA; $P < 0.05$).

per bale for IPM fields were more variable and not significantly different than conventional costs.

Cotton lint quality

Cotton fiber length, strength and micronaire (fiber width) did not differ between treatments in any year ($P > 0.05$). Overall fiber lengths (1/81 cm) were 36.13 ± 0.18, 35.68 ± 0.25 and 35.99 ± 0.22 for organic, IPM and conventional treatments, respectively. Fiber strength values (gtex) were 32.97 ± 0.41, 31.94 ± 0.25 and 32.03 ± 0.41 for organic, IPM and conventional treatments, respectively. Micronaire or fiber width values (μm) were 4.24 ± 0.05, 4.25 ± 0.08 and 4.08 ± 0.05 for organic, IPM and conventional treatments, respectively.

The percentage of bales that were of the best color grades of lint (11, 21 and 31) was significantly lower in the organic than in the conventional treatment in 1997, 1998 and 2001 (Fig. 4). This combined color grade series was also significantly lower in the IPM than in the conventional treatment in 1997 and 2001.

Bale leaf ratings from organic fields were significantly higher (reflecting more leaf contamination) than ratings from conventional fields in 1996 and 1997, and significantly higher than ratings from IPM fields from 1996 to 1998 (Fig. 5). Bale leaf ratings were significantly higher in conventional relative to IPM cotton in 1996 and 1998.

These differences in color grade and bale leaf rating were likely due to insufficient pre-harvest defoliation in organic fields, rather than differences in cotton boll development, as illustrated by non-significant treatment differences for cotton lint length, strength and width. The mineral and organic acids used as late-season nutritional crop preparation aids by organic growers were much less effective than the common chemical defoliants used by IPM and conventional growers in preventing plant material from contaminating lint. This lack of effective defoliation also required slower harvest machinery operation, and occasional repeated mechanical pickings.

Cotton lint yield

Cotton lint yields were significantly higher in conventional than organic fields from 1997 to 2001 (Fig. 6). A small

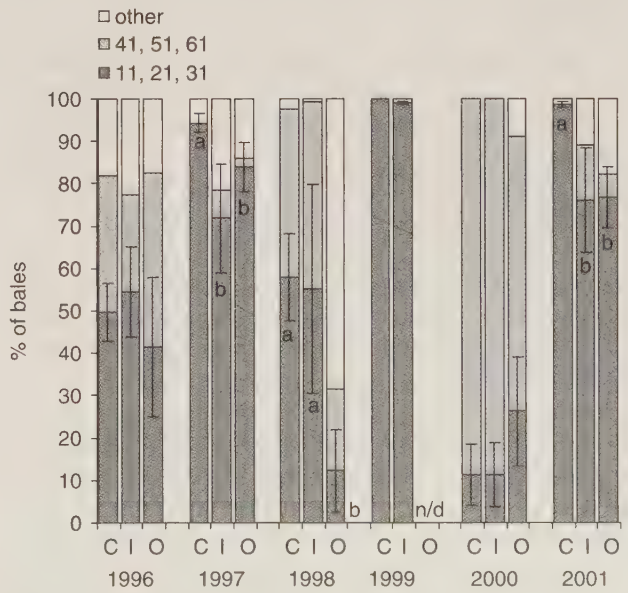

Figure 4. Average percentage cotton lint color grades (1996–2001). The grades 11, 21 and 31 represented the highest quality fiber, while 41, 51 and 61 represented the lowest. Different letters within years represent statistical differences for the grades 11, 21 and 31 between treatments (ANOVA; $P < 0.05$). C, conventional; I, IPM; O, organic.

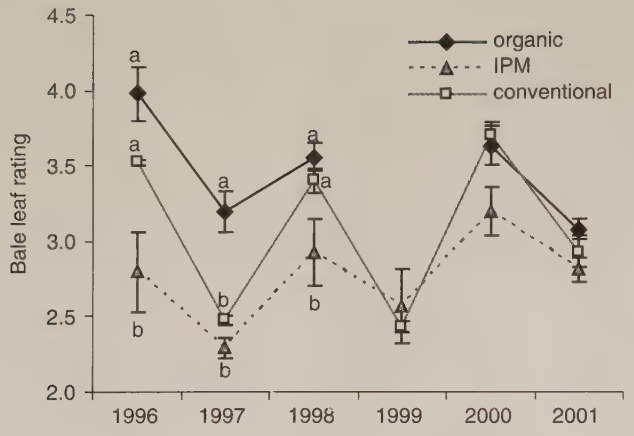

Figure 5. Average bale leaf ratings (1996–2001). Higher ratings represent greater cotton leaf contamination in the harvested lint. Different letters within years represent statistical differences between treatments (ANOVA; $P < 0.05$).

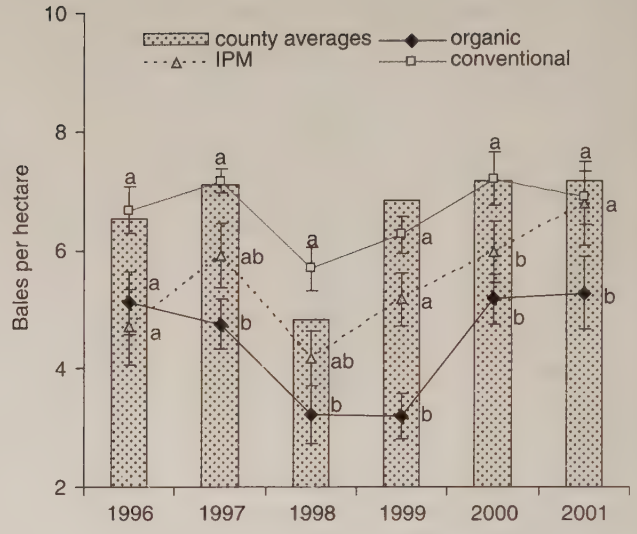

Figure 6. Average cotton yields from 1996 to 2001. One bale = 218 kg of cotton. Different letters within years represent statistical differences between treatments (ANOVA; $P < 0.05$). County values are averages of Madera and Merced counties, California.

sample size decreased our ability to detect treatment differences in 1996. Yields from conventional fields were also significantly higher than those from IPM fields in 2000. Average 6-year yields were 4.4, 5.4 and 6.7 bales ha^{-1} for organic, IPM and conventional treatments, respectively. Significant 6-year average yield differences between organic and conventional fields were 1.3 bales ha^{-1} (19% reduction) in IPM fields and 2.3 bales ha^{-1} (34% reduction) in organic fields, relative to yields in conventional fields ($P < 0.05$). Treatment yields in IPM and conventional fields consistently tracked average cotton yield trends for Madera and Merced counties during this study period.

Less than optimum weed management in organic fields may best explain the yield differences between conventional and organic treatments. Weed densities in organic fields were observed to be higher than either IPM or conventional fields in several years of this study. For example, johnsongrass (*Sorghum halepense*) is one of the most commonly encountered weeds in the NSJV, and is capable of reducing cotton yields by up to 90%[19]. Competition from other weeds in the NSJV, such as cocklebur (*Xanthium* spp.), amaranth (*Amaranthus* spp.) and pigweed (*Amaranthus* spp.) have also been shown to reduce cotton yields[20–22].

Methods for weed control available to organic growers are limited and are the most likely cause of higher weed densities. While machine cultivation is available and utilized by all growers during the earlier stages of cotton vegetative growth, only IPM and conventional growers use early season herbicide applications in tandem with herbicide-resistant cotton (beginning in 2000) to effectively reduce weed densities. Early season machine cultivation alone is not sufficient to suppress weed populations later in the growing season. Given the size and structure of cotton plants during later stages of development, machine cultivators are unable to remove weeds without damaging the crop. Therefore, organic growers become reliant on hand weeding, which can be cost-prohibitive.

Given the lack of significant differences between treatments for such cotton production parameters as the number of first position bolls and total bolls, increased weed pressure may best explain yield differences. Strategies that may raise yields in organic fields include timelier hand weeding, more frequent early season cultivation and adoption of innovative weed control technologies (flamers, organically compliant contact herbicides, etc.).

Summary and Conclusions

There proved to be two major future obstacles to the viability of growing cotton organically in the NSJV of California. Higher production costs, coupled with lower yields, established an economic necessity for a price premium for organic cotton. However, an abundance of relatively inexpensive overseas cotton (both organic and conventional) contributed to diminished market prices available to California cotton growers from 1996 to 2001. During this study, global cotton market prices reached a 30-year record low ($0.97 kg^{-1})[1]. Organic growers participating in this study required as much as $2.42 kg^{-1} to ensure a profit after accounting for storage, brokerage and other opportunity costs (Claude Sheppard, personal communication). From 1999 to 2004, there was a 78% reduction in California certified organic cotton hectares[2]. In 2004, approximately 41 ha of registered organic cotton remained in the NSJV (in Madera County), and only 111 ha remained statewide[2]. The discrepancy between costs and prices awarded illustrates the current lack of marketplace-mediated incentives to encourage certified organic

production practices. There are also no current means to integrate environmental costs into the market price of conventionally managed cotton, which would also help to bridge this price gap.

Synthetic insecticide applications were reduced by IPM growers, who applied 38% fewer kg AI per hectare than did conventional growers. Organic growers used no synthetic insecticides. However, in the majority of comparison intervals, pest insect abundance in organic or IPM fields was equivalent to abundance in conventional fields, and only rarely exceeded action thresholds. This reduction and/or elimination of insecticides also conserved beneficial insects in the IPM and organic fields, particularly in the latter. This study demonstrated that both a supervised IPM program and certified organic production resulted in successful insect pest management in cotton from 1996 through 2001, while substantially reducing insecticide applications in the NSJV.

There were significant differences in the cost of production between management strategies. Six-year averages of costs per bale were significantly higher for the organic than for the IPM or conventional treatments. This increase in costs in the organic treatment (37% greater than conventional costs) was mainly due to lower yields, higher costs for labor (for hand-weeding crews) and pre-harvest custom applications (of compost and sulfur). Higher materials costs (synthetic insecticides) were accrued in conventional and IPM fields.

Cotton yields were also significantly lower in organic fields than either IPM or conventional fields. The lower yields in organic fields were likely due to lower plant densities and higher weed pressure. Yields from IPM fields were significantly lower than those from conventional fields, although the difference was smaller.

This multi-year study illustrates the potential for insecticide use savings in IPM and organic cotton, and the yield potential for these alternative production systems in the NSJV. Organic cotton in the NSJV had lower yields and higher costs of production. Low world market prices that prevent premiums from being offered for NSJV organic cotton are the primary obstacle to its continued production.

Acknowledgements. We would like to thank Claude and Linda Sheppard, Pete Cornaggia and other cotton growers for participating in this study, and the BASIC program for helping to recruit growers for participation. We would also like to thank Richard Nathanson for assistance with data analysis, and John Bailey, Merrilee Buchanan, Jennifer Charles, Amy Griggs, Amanda Lewis, Eri Mizuno, and BASIC program personnel for their assistance with fieldwork. This research was funded in part by the US-Environmental Protection Agency (EPA) Region IX grant no. NP-98932201-1. We thank Paul Feder and James Liebman (US-EPA Region 9) for their assistance with this project.

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Renewable Agriculture and Food Systems: 22(1); 41–53 doi:10.1017/S1742170507001585

Influence of cover crops and soil amendments on okra (*Abelmoschus esculentus* L.) production and soil nematodes

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Accepted 6 March 2006 **Research Paper**

Abstract

A pot experiment to determine the effects of summer cover crops and soil amendments on okra yields and population densities of various soil nematode taxa was conducted in two consecutive growing seasons in a subtropical region. Two cover crops, sunn hemp (*Crotalaria juncea*) and sorghum sudangrass (*Sorghum bicolor* × *S. bicolor* var. sudanense), were grown and returned to the soil with fallow as a control. As soon as these cover crops were harvested, they were soil-incorporated together with one of several organic amendments. These organic amendments were biosolids, N-Viro soil (a 1 : 1 mixture of coal ash and biosolids), coal ash, co-compost (a 3 : 7 mixture of biosolids and yard wastes), and yard waste compost compared with a control (no additional amendment). Other treatments were fumigation with MC-33 (a mixture of 33% of methyl bromide and 67% of chloropicrin) and cover crop removal (harvested and removed cover crops and their residues from the soil). A nematode-susceptible vegetable crop, okra (*Abelmoschus esculentus* L.), was grown under these treatments. Among organic amendments, the application of biosolids produced the highest okra yield and biomass, and greatly suppressed root-knot nematodes, *Meloidogyne incognita*, in the soil. Between these two cover crops, sunn hemp was superior to sorghum sudangrass in improving okra production and in suppressing root-knot nematodes. The result indicates that growing sunn hemp as a cover crop and applying certain organic amendments can improve okra production and suppress root-knot nematodes, which are very damaging to okra plants. Such combined practices show a significant potential for application in organic farming and sustainable agriculture systems in a tropical or subtropical region.

Key words: amendments, biosolids, composts, coal ash, cover crop, nematode, okra

Introduction

Soil organic amendments, e.g. biosolids, composts, etc., are a valuable source of plant nutrients, particularly N and some micronutrients, which can provide essential nutrition to crops through decomposition. However, the plant available nutrients supplied by these amendments vary considerably depending on their components and mineralization rate[1]. Cover crops, commonly used as green manures, are also important soil organic amendments for sandy or gravelly soils in Florida, USA[2]. The C : N ratio in green manure or compost amendments usually plays a vital role in controlling the decomposition and nutrient release rates[3]. Biosolids resulting from the treatment of waste water or sewage sludge contain higher amounts of N and of some other nutrients, which had a lower C : N ratio than regular composts. Biosolids usually combine with other organic materials, such as green and woody wastes, and act much like slow-release organic fertilizers[4]. Other composted municipal solid wastes (paper, cardboard, food waste, yard waste, textiles, etc.), including yard waste compost (mainly from leaves and branches of trees and shrubs, and grass

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clippings) and coal ash or fly ash (a byproduct from power plants) when used as soil amendments have shown a high potential to improve soil fertility and crop production[5,6]. These materials may serve as a partial substitute for inorganic fertilizer for tomatoes[7] and bell peppers[8], and as general soil conditioners[4]. Vegetable crop yield responses to such amendments have been evaluated for many crops, including tomato, bell pepper, broccoli, sweet corn, cucumber, eggplant, okra, snap bean, squash and watermelon[9].

Compost production has become a promising industry. In the State of Florida alone, over 27 million $t\,yr^{-1}$ of solid waste is produced, which is about 4.5 kg per capita per day[10]. The generation of municipal solid wastes is increasing rapidly in step with the rapid rate of population growth in this state. However, since Florida is a major vegetable-producing state, with 418,000 acres under cultivation each year[10], there is a great potential to utilize composts. According to USEPA, 30–60% of a community's municipal solid wastes can be processed as municipal solid waste composts[11]. The agricultural industry is the largest consumer of those composts and has the potential to use up to 800 million m^3 annually, which is more than 10 times the US production of solid waste composts[12,13].

Numerous studies have demonstrated that the application of composts can increase soil organic matter[14,15], cation exchange capacity[16], soil water-holding capacity[17,18], pH of acidic soils[15] and soil microbial[19] and enzymatic activities[18] and decrease soil bulk density[17]. The application of these composts usually does not contaminate soils, edible crops or groundwater with pathogens or heavy metals[6,25]. Crop responses to different composts vary widely: from induced N-deficiency in pepper[20] to yield increases of 22% in snap bean and 38% in tomato[15]. On the other hand, applications of certain composts—because of immaturity or a high C:N ratio—may lead to the immobilization of soil mineral N[21,22] and thereby induce N-deficiencies in plants and depress crop yields[20].

Soil nematodes, especially root-knot nematodes (*Meloidogyne* spp.), are major soil-borne pests that damage crops and significantly diminish yields. Indeed plant-parasitic nematodes cause annual crop losses estimated at approximately $78 billion worldwide and $8–$12 billion in the United States[23]. However, certain cover crops as green manure have been shown to improve soil fertility and crop yields[3,24,25], as well as suppress plant-parasitic nematodes[26–29]. Certain compost amendments have also been found to suppress soil-borne nematodes and plant pathogens[30–33], and some researchers have suggested that it may be possible to develop their use as reliable alternatives to methyl bromide for soil fumigation in vegetable production systems[2,34]. Therefore, the objective of this experiment was to elucidate the effect of growing certain green manure crops and the application of various organic soil amendments on okra yields and on the population densities of various soil nematode taxa.

Materials and Methods

Soil properties

The soil used in this experiment was Krome, very gravelly loam (loamy-skeletal, carbonatic, hyperthermic Lithic Udorthents) collected from a field in the Tropical Research and Education Center, University of Florida, Homestead, FL, USA. The soil contained 58.8% gravel (>2 mm) and was composed of 48.4% sand, 30.3% silt and 21.3% clay in the fine earth (gravel-free) fraction. Also the soil contained 60% $CaCO_3$, pH 7.8 (water), soil organic C 28 $g\,kg^{-1}$, total N 1.1 $g\,kg^{-1}$, and ammonium bicarbonate-diethylene triamine pentaacetic acid (AB-DTPA) extractable P 22.7 $g\,kg^{-1}$ and K 129 $g\,kg^{-1}$, respectively. Since the populations of root-knot nematodes (*Meloidogyne incognita*) in the field were known to be quite low[29,31], plant roots of tomatoes with root galls caused by root-knot nematodes were collected from several farms in Miami-Dade County of Florida, and pieces of these roots were uniformly distributed to the pot soil to increase the nematode population. The experiment was conducted with 8.3-liter black plastic pots 23 cm in diameter and 20 cm high with a capacity of 8 kg of soil per pot.

Experimental design

A split plot design was conducted with 24 pots for each of two cover crops and a fallow (control) treatment as main plots. Eight soil amendment treatments were applied to each cover crop as subplots. Three replicates were conducted for each treatment. Summer cover crops were sunn hemp (*Crotalaria juncea* L.) and sorghum sudangrass [*Sorghum bicolor* × *S. bicolor* var. sudanense (Piper) Stapf.] compared with fallow soil (control). The amendments were biosolids, N-Viro soil (a 1 : 1 mixture of coal ash and biosolids), coal ash, co-compost (a 3 : 7 mixture of biosolids and yard wastes), yard waste compost (YW-compost), control (cover crop grown and incorporated into the soil, but without any other organic amendment), cover crop removal (the cover crop was grown and aerial parts together with roots were removed from the soil), and MC-33 (fumigated with a mixture of 33% of methyl bromide and 67% of chloropicrin after the cover crop was grown and incorporated into the soil).

Experimental management and growth conditions

These two cover crops, sunn hemp and sorghum sudangrass, were seeded on June 10, 2002 and June 17, 2003, and the okra was seeded on September 18, 2002 and September 30, 2003 for every treatment. These cover crops were harvested at the stage of sunn hemp flowering, and cut into pieces (<2 cm) before mixing into the soil together with one of the following organic amendments: biosolids, N-Viro soil, coal ash, co-compost, yard waste compost, control (cover crop only without any amendment), cover crop removed and MC-33. The amount of each organic

Table 1. Characteristics, nutrient and trace metal concentrations of soil amendments used in the experiment.

	Biosolids	N-Viro soil	Co-compost	YW-compost[4]	Coal ash
pH	6.1	9.2	6.7	7.7	11.8
EC ($mS\,cm^{-1}$)[1]	16.1	6.4	1.0	1.7	5.4
	---------- $mg\,kg^{-1}$ ----------				
Extractable N[2]	1461.2	13.8	145.9	29.0	6.4
Extractable P	236.6	209.1	130.3	85.9	8.9
Total P[3]	29,080	5430	13,433	729	156
Total Ca	43,179	115,122	44,133	153,614	161,294
Total Mg	3774	1814	2452	2027	1781
Total Fe	8387	9094	13,210	5559	6985
Total Zn	1254	168	347	598	69
Total Mo	11.4	12.0	6.0	3.4	18.7
Total Co	2.8	16.6	2.6	4.5	41.5
Total Cd	3.6	1.7	1.8	1.8	1.6

[1] EC, electrical conductivity. The ratio of soil to water was 1:2.
[2] N was extracted by 2.0 *M* KCl; extractable P was extracted with ammonium bicarbonate–DTPA, and determined by means of AA3.
[3] Total content of elements was determined by means of ICP after samples were digested with the EPA 3050A method.
[4] YW, yard waste.

amendment added to the soil was 205 $g\,pot^{-1}$ of dry weight basis, equivalent to 50 $t\,ha^{-1}$. After the cover crop residues and/or organic amendments were incorporated into the soil, the amended soil was allowed to equilibrate for 10 days before the okra (*Abelmoschus esculentus* L.) was seeded. The composition and properties of the various organic amendments were determined and are summarized in Table 1. More detailed information can be found in Wang et al.[25]. In the MC-33 treatment, the pots were fumigated by placing them into a chamber and using liquid N to introduce the appropriate amount of the 33% methyl bromide and 67% chloropicrin mixture after cover crops were incorporated into the soil. The chamber was kept hermetically sealed for 72 h. Thereafter the pots were exposed to the atmosphere for an entire week, and then okra was seeded. The okra planting was thinned at the three-leaf stage to six plants per pot. Drip irrigation was installed and adjusted to deliver 2 liter h^{-1} of water. A clock timer was used to control the irrigation automatically. The period and frequency of irrigation were adjusted according to needs of the successive plant growth stages. Okra fruits were harvested when they attained full development.

The experiment was carried out from June 2002 to February 2003 as the first year (Year-1), and from June 2003 to February 2004 as the second year (Year-2) in a screen house at Homestead, FL, USA, which is a subtropical region. The average annual rainfall is 1499 mm, of which 76% falls between June and October, the average annual temperature is 23.9°C with a range from a maximum of 35°C in June to a minimum of 5°C in January[24]. During these two growing seasons between June 2002 and February 2004, the air temperatures ranged from a minimum of 2.2°C to a maximum of 34.6°C with 1084.6 mm rainfall in Year-1, and from a minimum of 2.9°C to a maximum of 33.3°C with 1319 mm rainfall in Year-2. Monthly average temperatures were 35.3 and 34.1°C as maximum both in August of 2002 and August of 2003; and 28.5 and 28.6°C as minimum both in January of 2003 and January of 2004; relative humidity fluctuated between 75% (January) and 84% (June) in Year-1 and 77% (December) and 84% (August and September) in Year-2; the maximum solar radiation was 216 $W\,m^{-2}$ in August 2002 and 224 $W\,m^{-2}$ in July 2003; and the minima were 128 $W\,m^{-2}$ in December 2002 and 129 $W\,m^{-2}$ in December 2003.

Sampling and analysis

Each cover crop was sampled for biomass determination before the harvest and incorporation into the soil. Okra fruits were harvested to obtain the fruit yield. The okra yields and cover crop biomass weights were converted to metric tons per hectare ($t\,ha^{-1}$) equivalent based on the surface area of the pot. For determining the identities and densities of the various nematode taxa, soil samples were collected at three stages: (1) before the cover crops were seeded, (2) after cover crops were grown and (3) immediately after the okra harvest. A soil sample was taken from 5 to 15 cm below the surface of each pot. Nematodes from each sample were extracted by means of Cobb's sieving and decanting technique[35], followed by a modified Baermann funnel method[36]. Sieves used in nematode extraction were US Standard Sieve Series of 100, 200 and 325 mesh with openings of 149, 74 and 44 µm, respectively. Nematodes were fixed in hot 30 $ml\,l^{-1}$ of formaldehyde solution, identified to genus level and counted using a stereoscope. Some fixed specimens were processed with anhydrous glycerin[37], and examined under a compound microscope for species identification. Nematode identifications were based on the morphology of adult and larval forms and their identities were confirmed with recent taxonomic keys[38–42]. Roots were washed free of soil and examined for galling and root-knot infection. Some roots showing lesions were cut into small pieces and left

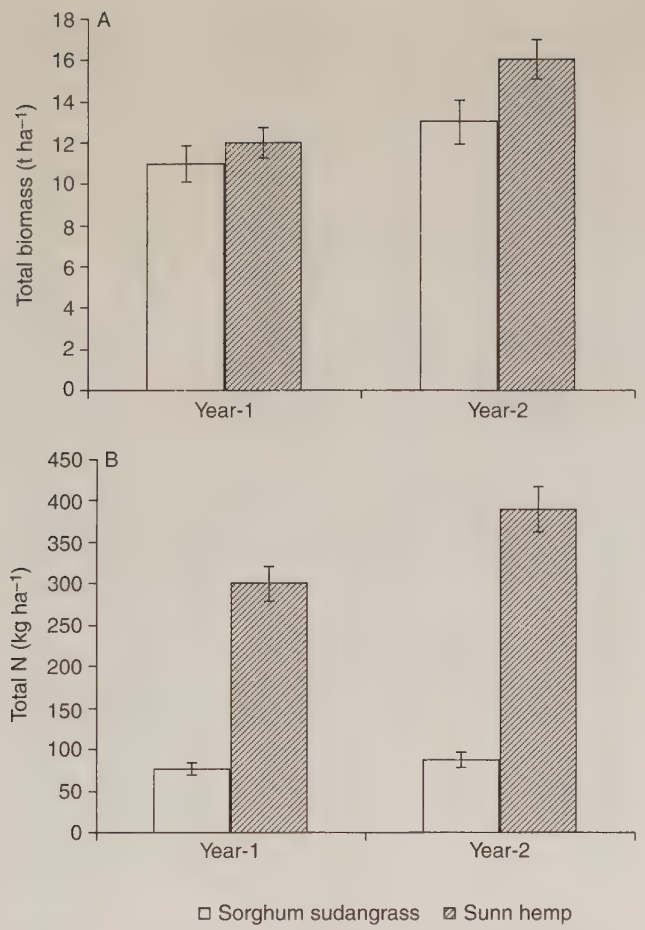

Figure 1. Total amounts of biomass (A) and N (B) accumulated by cover crops and returned to the soil in Year-1 and Year-2. The vertical bars represent standard errors of the mean values ($n = 3$).

in water for 36–48 h to reveal the presence of any lesion and other nematodes. Nematode density (number in 250 ml of soil) was determined for each species and recorded. The okra plants were individually rated for root galls and egg masses on a 0–5 scale: 0 = 0 galls, 1 = 1–2, 2 = 3–10, 3 = 11–33, 4 = 31–100, and 5 > 100 galls or egg masses[43].

Statistics

The data were subjected to the analysis of variance (ANOVA) and Duncan's multiple range tests for a significant difference at $P < 0.05$ by means of the SAS program[44].

Results

Cover crop biomass production and nutrient contents

There were no significant differences in biomass production between sunn hemp and sorghum sudangrass in this experiment in either of the 2 years (Fig. 1). In years 1 and 2, sunn hemp produced the equivalent of 12 and 16 t ha^{-1} of dry weight biomass, respectively, while sorghum sudangrass correspondingly produced 11 and 13 t ha^{-1}. However, the total amounts of N accumulated and returned to the soil by these two cover crops were significantly different because sunn hemp contains about 3 times the N concentration of sorghum sudangrass, i.e., 2.85 versus 0.92%[3]. Thus the total amounts of N returned to the soil in plant biomass were equivalent to 300–390 kg ha^{-1} from sunn hemp versus 77–87 kg ha^{-1} from sorghum sudangrass in both years (Fig. 1). However, the amounts of P and other elements returned in these two cover crops were similar (data not shown).

Okra yields influenced by green manure and organic amendments

Results of the ANOVA (Table 2) showed that yields of okra were significantly affected by these two cover crops, as well as by various organic amendments, but the interaction between cover crops and organic amendments was not significant.

Okra yields (Table 3) under all treatments were generally higher in the second year than in the first. Compared to the fallow, growing sunn hemp increased okra fruit yields in both years and growing sorghum sudangrass increased okra fruit yield in the second year as well.

In contrast to the control, some soil amendments, especially biosolids, increased the okra yield dramatically in both years; all the other treatments of soil amendments significantly increased okra yields in both years except those of coal ash and yard waste compost in the second year (Table 3). However, we noted that treatments of sunn hemp combined with an organic amendment that has a low N content [e.g. N-Viro (13.8 mg kg^{-1}), coal ash (6.4 mg kg^{-1}), or yard waste compost (29 mg kg^{-1})] resulted in a higher okra yield than treatments of sorghum sudangrass combined with the same organic amendment. In contrast, treatments of sunn hemp combined with an organic amendment that has a high N content [e.g. biosolids (1461 mg kg^{-1}) or co-compost (146 mg kg^{-1})] did not result in a significantly higher yield of okra than treatments of sorghum sudangrass combined with the same organic amendment (data not shown).

Effects on levels of root galling by cover crops and organic amendments

Significantly less root galling of okra was found with treatments of sunn hemp rather than sorghum sudangrass (Figs. 2A and 3A), which indicates that sunn hemp possesses one or more mechanisms to resist root-knot nematodes. The most important finding is that this function can last long enough to protect the subsequent nematode-susceptible cash crop.

Root galling in the biosolids treatment in both years (Figs. 2B and 3B) was quite low and statistically similar to

Table 2. ANOVA on the effect on okra yield of cover crops, organic amendments and interactions of these two factors.

Source	DF	Sum of squares	Mean square	*F*-value	Pr>*F*
Cover crops	1	556.710708	556.710708	41.95	<0.0001
Organic amendments	7	3972.813119	567.544731	42.76	<0.0001
Cover crops × Organic amendments	7	111.093154	15.870451	1.20	0.3352
Replicates	2	3.073936	1.536968	0.12	0.8910

Table 3. Okra yields ($t\,ha^{-1}$) of various cover crop–organic amendment combinations.

	Okra fruit yield ($t\,ha^{-1}$)	
Organic amendment	**Year-1**	**Year-2**
Cover crops		
Sunn hemp	7.21 a[1]	13.25 a
Sorghum sudangrass	5.32 ab	8.21 b
Fallow	4.03 b	5.16 c
Soil amendments		
Biosolids	20.32 a	26.29 a
N-Viro soil	13.29 b	13.21 b
Coal ash	10.18 c	12.14 bc
Co-compost	12.34 b	13.21 b
Yard waste compost	12.28 b	12.19 bc
Control (cover crop only)	6.15 d	11.26 c
Cover crop removed[2]	5.02 d	9.04 d
MC-33	10.88 c	15.37 b

[1] Data with same letters in the same column for cover crops or soil amendments represent insignificant differences at $P \leqslant 0.05$.
[2] The cover crop was grown until the sunn hemp flowering stage for its harvest. At that time, both shoots and roots were removed and discarded.

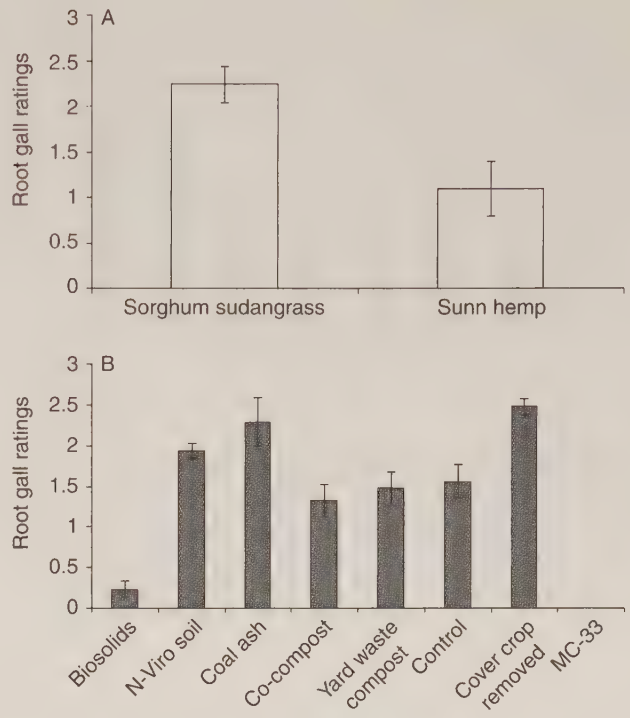

Figure 2. Root gall ratings of okra influenced by cover crops (A) and soil amendments (B) in the first year experiment. Vertical bars represent standard errors of means. Root rating scale (0–5): 0 = 0 galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5>100 galls or egg masses of the root-knot nematode, *Meloidogyne incognita*.

that in the MC-33 treatment. Root galling was very high in the treatment of cover crop removed in both years (Figs. 2B and 3B). In the experiment of the second year, the levels of root galling in the biosolids and coal ash treatments were not significantly different from that in the MC-33 treatment (Fig. 3B).

Effects of cover crops and organic amendments on population densities of different soil nematode taxa

The total number of nematodes decreased after sorghum sudangrass was grown (Table 4), and the total numbers of both plant parasitic and non-parasitic nematodes were suppressed. Although sorghum sudangrass did not cause a decline in the density of *M. incognita*, it did not allow a substantial build up of this or any other taxon of plant-parasitic nematode. In contrast, the sunn hemp treatment reduced the aggregate total number of nematodes slightly, but strongly suppressed the parasitic nematode taxa, and allowed the mycophagous *Aphelenchus avenae* and the bactivorous rhabditids to thrive (Table 4). The taxa of plant-parasitic nematodes that were present before sunn hemp was grown, but that could not be detected after sunn hemp had been grown, were the root-knot nematode (*M. incognita*), the stunt nematode (*Quinisulcius acutus*) and the reniform nematode (*Rotylenchulus reniformis*). After okra had been grown in soil containing sorghum sudangrass or sunn hemp residues or in fallow, the total numbers of plant-parasitic and non-parasitic nematodes had increased dramatically in all these treatments; these two cover crops did not cause a significant difference in the total number of parasitic nematodes but the population of non-parasitic nematodes in the sunn hemp treatment was significantly higher than that in the sorghum sudangrass treatment (Table 4).

The MC-33 treatment significantly suppressed the total number of parasitic nematodes but increased the population of *R. reniformis* after okra had been grown. However, the suppression of root-knot nematode (*M. incognita*) by

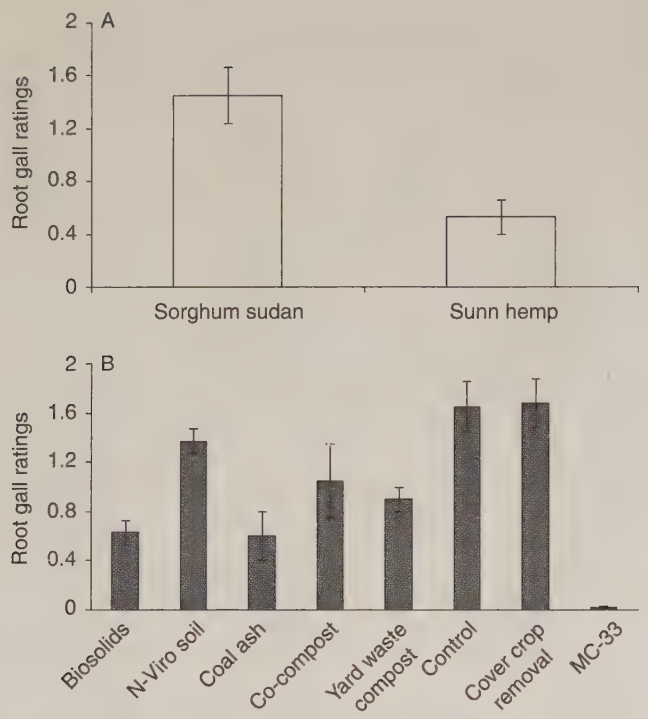

Figure 3. Root gall ratings of okra influenced by cover crops (A) and soil amendments (B) in the second year experiment. Vertical bars represent standard errors of means. Root rating scale (0–5): 0 = 0 galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 > 100 galls or egg masses of the root-knot nematode, *Meloidogyne incognita*.

the MC-33 treatment was not significantly different from the treatment with biosolids (Table 4).

In the first year experiment, under treatments of sorghum sudangrass combined with various organic amendments (Table 5), the treatment of MC-33 significantly suppressed the total and parasitic nematode population compared to all other treatments, and especially reduced the population of root-knot nematode (*M. incognita*). In contrast, under treatments of sunn hemp combined with various organic amendments, the application of biosolids showed a superior suppression on root-knot nematodes, *M. incognita*, which was as effective as the treatment fumigated with MC-33 but the population of the stunt nematode (*Quinisulcius acutus*) was significantly increased (Table 5). The highest populations of root-knot nematode were found in the cover crop removed treatment although the difference between this treatment and others, except biosolids, coal ash and MC-33 were insignificant. The treatment of coal ash combined with sunn hemp showed a significant reduction in root-knot nematode (*M. incognita*) population versus the treatment of cover crop removed (Table 5).

In the second year experiment, although combinations of cover crops with various organic amendments (Table 6) produced some inconsistent effects compared with the first year, the treatment of MC-33 with either of those two cover crops had the lowest population of root-knot nematodes, *M. incognita*, and the total numbers of parasitic nematodes were significantly lower than those with some other treatments except the treatment of biosolids combined with sunn hemp. The combination of sunn hemp with biosolids reduced the population of root-knot nematodes (*M. incognita*) and the total number of parasitic nematodes, which produced the same result as the treatment of sunn hemp combined with MC-33 (Table 6). Also, besides the treatments of MC-33 and biosolids, the application of coal ash or co-compost showed a significant reduction of the total number of parasitic nematodes compared to treatments of yard waste compost, control or cover crop removed.

In both years of the experiment, the number of *Aphelenchus avenae* nematodes was generally improved by growing sunn hemp compared to sorghum sudangrass regardless of treatments with various organic amendments (Tables 4–6).

Discussion

Sunn hemp usually produces significantly higher amounts of biomass than sorghum sudangrass when grown in the field. For example, Wang et al.[24] obtained 12 t ha^{-1} of sunn hemp biomass versus 5 t ha^{-1} of sorghum sudangrass from a field experiment. The difference in biomass production in pots and in the field might be related to respective differences in growing conditions. Since sunn hemp is a tropical crop, its vegetative growth and development are favored by hot and humid summers and relatively long day lengths as occur from June through September in south Florida. Sunn hemp appears to grow less well in pots than sorghum sudangrass.

Yield responses of vegetable or field crops to the application of soil organic amendments have been reported by a number of researchers. For instance, Warman[45] reported that with compost amendments in field plots, marketable carrot yields were increased from 67 to 76%, compared to those from fields amended with the conventional fertilizers. Maynard[15] reported that over a 3-year period, the average tomato fruit yields from compost-amended plots ranged from 4.89 to 8.85 kg per plant compared with 3.54 to 7.67 kg per plant in the control, and the average yield increase in compost-amended plots was 18%. In Washington State, barley and wheat yields increased by 35% when prior to planting each year a form of sewage sludge was ploughed into the field at a rate of 4.5 t ha^{-1} dry weight equivalent[46]. Many trials have been performed using municipal solid waste and various composts as soil amendments[9,47–49]. However, most of these studies focused on improvements in soil quality rather than on differences in crop performance[4].

The significant improvement of okra fruit yield achieved by growing sunn hemp in both years indicates that the high N contribution from sunn hemp residues can be a main factor to improve okra yields. Also the dramatic increase in okra fruit yields under the treatment of biosolids implies that a high N requirement of okra can be met by application

Table 4. Population densities (number per 250 ml) of different soil nematode taxa before and after various treatments with cover crops and organic amendments.

	Aphelenchus avenae	*Helicotylenchus dihystera*	*Meloidogyne incognita*	*Quinisulcius acutus*	*Rotylenchulus reniformis*	*Heterodera* sp.	*Tylenchus sandneri*	Dorylaimids	Rhabditids	Total	Subtotal parasitic[1]	Subtotal non-parasitic
Before cover crops were grown												
	22.0	24.3	7.0	16.0	4.3	–	6.3	9.7	14.3	104.4	51.7	52.3
When the cover crops were terminated												
Sorghum sudangrass	0.3 b[2]	0.0	8.8 a	0.3 a	0.0	–	0.0	0.0 a	4.6 b	13.9 b	9.1 a	4.8 b
Sunn hemp	29.5 a	0.0	0.0 b	0.0 a	0.0	–	0.0	2.0 a	60.5 a	92.0 a	0.0 b	92.0 a
Fallow (control)	0.0 b	0.0	0.0 b	0.0 a	0.0	–	0.0	0.0 a	3.0 b	3.0 c	0.0 b	3.0 b
After okra had been grown in soil containing cover crop residues or on fallow												
Sorghum sudangrass	0.0 b	33.7 b	423.3 a	50.4 b	–	–	1.5 b	59.0 a	63.4 a	575.1 ab	470.8 a	104.3 b
Sunn hemp	10.0 a	50.0 b	193.3 b	157.2 b	–	–	7.5 a	38.3 a	129.0 a	736.0 a	543.9 a	192.1 a
Fallow (control)	3.3 b	151.7 a	35.0 b	265.0 a	–	–	0.0 b	60.0 a	77.6 a	396.5 b	301.3 a	95.2 b
After okra had been grown in soil containing both cover crop residues and various organic materials[3]												
Biosolids	13.3 ab	75.8 ab	46.7 b	325.0 a	0.0 b	0.0 a	10.0 a	17.0 a	87.5 a	575.3 ab	447.5 a	127.8 a
N-Viro soil	6.7 ab	93.3 a	265.0 ab	165.0 b	0.0 b	160.0 a	2.5 a	45.8 a	92.2 a	830.5 a	683.3 a	147.2 a
Coal ash	30.0 a	94.2 a	190.8 ab	73.3 b	0.0 b	275.0 a	10.0 a	40.8 a	94.4 a	808.5 a	633.3 a	175.2 a
Co-compost	13.3 ab	93.3 a	200.5 ab	80.0 b	0.0 b	385.0 a	11.7 a	52.5 a	85.6 a	921.9 a	758.8 a	163.1 a
YW-compost	20.0 ab	56.7 ab	234.2 ab	118.0 b	0.0 b	433.0 a	0.0 a	52.5 a	110.3 a	1025.0 a	842.2 a	182.8 a
Cover crop only (control)	13.4 ab	68.9 ab	186.8 ab	93.1 b	0.0 b	262.3 a	3.3 a	35.7 a	83.0 a	746.5 ab	611.1 a	135.4 a
Cover crop removed	14.1 ab	53.3 ab	374.6 a	46.2 b	0.0 b	259.0 a	2.5 a	44.7 a	59.9 a	854.3 a	733.1 a	121.2 a
Cover crop + MC-33	1.2 b	10.8 b	66.8 b	45.9 b	6.3 a	0.0 a	0.0 a	19.7 a	150.1 a	300.8 b	129.8 b	171.0 a

[1] Plant parasitic nematodes include *Helicotylenchus dihystera*, *Heterodera* sp., *Meloidogyne incognita*, *Pratylenchus neglectus*, *Quinisulcius acutus*, *Rotylenchulus reniformis* and *Tylenchus sandneri*, and non-plant parasitic nematodes include Dorylaimids, *Mononchus* and Rhabditids, respectively, if any identified.

[2] Data followed by same letters within a column represent insignificant differences at $P \leq 0.05$.

[3] Pooled data from three replicates involving either sorghum sudangrass or sunn hemp as green manure to which an organic amendment was added.

Table 5. Effects of cover crops combined with various organic amendments on the population densities (number per 250 ml) of different soil nematode taxa in the first year experiment.

	Aphelenchus avenae	*Helicotylenchus dihystera*	*Meloidogyne incognita*	*Quinisulcius acutus*	*Heterodera* sp.	*Tylenchus sandneri*	Dorylaimids	Rhabditids	Total	Subtotal parasitic[1]	Subtotal non-parasitic
With sorghum sudangrass											
Biosolids	–	51.7 a	93.3 a	125.0 a	0.0 a	0.0 a	28.3 a	36.7 a	335.0 ab	270.0 ab	65.0 a
N-Viro soil	–	58.3 a	80.0 a	55.0 ab	160.0 a	5.0 a	31.7 a	26.0 a	416.0 ab	358.3 ab	57.7 a
Coal ash	–	98.3 a	136.7 a	30.0 b	275.0 a	0.0 a	31.7 a	73.5 a	645.2 ab	540.0 a	105.2 a
Co-compost	–	45.0 a	100.0 a	51.7 ab	385.0 a	–	31.7 a	48.0 a	562.3 ab	482.7 ab	79.7 a
YW-compost	0.0 b[2]	28.3 ab	135.0 a	66.7 ab	433.3 a	–	30.0 a	88.3 a	880.7 a	762.4 a	118.3 a
Control	0.0 b	33.7 ab	193.3 a	30.7 b	262.3 a	–	59.0 a	51.7 a	630.7 ab	520.0 a	110.7 a
Cover crop removed	12.3 a	28.3 ab	231.7 a	42.3 b	259.0 a	–	44.0 a	63.3 a	680.9 a	561.3 a	119.7 a
MC-33	1.7 b	20.0 b	1.0 b	1.7 b	–	0.0 a	25.0 a	43.4 a	92.7 c	22.7 c	70.0 a
With sunn hemp											
Biosolids	13.3 a	100.0 ab	0.0 c	525.0 a	–	20.0 a	5.7 b	86.7 b	750.7 ab	645.0 ab	105.7 a
N-Viro soil	6.7 a	128.3 a	450.0 ab	275.0 b	–	0.0 a	60.0 ab	101.7 b	1021.7 a	853.3 a	168.4 a
Coal ash	30.0 a	90.0 ab	245.0 bc	116.7 bc	–	13.3 a	50.0 ab	103.3 b	648.3 ab	465.0 b	183.3 a
Co-compost	13.3 a	141.7 a	400.0 ab	108.3 bc	–	11.7 a	73.3 a	123.3 b	871.7 a	661.7 ab	209.9 a
YW-compost	26.7 a	85.0 ab	333.3 abc	170.0 bc	–	0.0 a	75.0 a	128.3 b	818.3 ab	588.3 ab	230.0 a
Control	10.0 a	50.0 bc	423.3 ab	51.7 c	–	3.3 a	38.3 ab	85.0 b	661.6 ab	528.3 ab	133.3 a
Cover crop removed	5.0 a	26.7 bc	616.7 a	10.7 c	–	2.5 a	30.0 ab	63.4 b	755.0 ab	656.6 ab	98.4 a
MC-33	0.0 a	0.0 c	3.3 c	0.0 c	–	–	3.3 b	340.3 a	347.0 b	3.3 c	343.6 a

[1] Plant parasitic nematodes include *Helicotylenchus dihystera*, *Heterodera* sp., *Meloidogyne incognita*, *Pratylenchus neglectus*, *Quinisulcius acutus*, *Rotylenchulus reniformis* and *Tylenchus sandneri*, and non-plant parasitic nematodes include Dorylaimids, *Mononchus* and Rhabditids, respectively, if any identified.

[2] Data followed by same letters within a column represent insignificant differences at $P \leqslant 0.05$.

Table 6. Effects of cover crops combined with various organic amendments on the population densities (number per 250 ml) of different soil nematode taxa in the second year experiment.

	Aphelenchus avenae	*Helicotylenchus dihystera*	*Meloidogyne incognita*	*Rotylenchulus reniformis*	Dorylaimids	Rhabditids	Total	Subtotal parasitic[1]	Subtotal non-parasitic
With sorghum sudangrass									
Biosolids	1.7 a[2]	7.3 a	35.0 bc	88.3 abc	68.3 a	40.0 b	200.6 ab	130.6 ab	70.0 b
N-Viro soil	0.7 a	3.0 ab	46.7 b	78.3 abc	64.3 a	35.0 b	193.0 ab	128.0 ab	65.0 b
Coal ash	1.3 a	0.7 b	125.0 a	100.0 abc	100.0 a	58.3 b	327.0 a	225.7 a	101.3 a
Co-compost	0.0 a	1.0 b	65.0 ab	126.7 ab	103.0 a	34.7 b	295.7 a	192.7 a	103.0 a
YW-compost	0.0 a	0.7 b	44.0 b	40.3 bc	53.0 a	19.0 b	138.0 b	85.0 b	53.0 b
Control	0.0 a	1.3 b	46.0 b	81.0 abc	80.7 a	35.7 b	209.0 ab	128.3 ab	80.7 a
Cover crop removed	0.0 a	2.7 ab	85.0 ab	156.7 a	99.4 a	46.7 b	343.8 a	244.4 a	99.4 a
MC-33	1.0 a	0.0 b	1.0 c	1.3 c	221.4 a	131.7 a	224.7 ab	2.3 c	222.4 a
With sunn hemp									
Biosolids	13.3 b	17.3 a	23.7 bc	25.0 a	276.7 b	160.0 b	338.0 ab	48.0 bc	290.0 b
N-Viro soil	20.7 b	0.0 b	106.7 ab	10.0 a	426.3 a	138.3 b	564.0 a	116.7 ab	447.3 ab
Coal ash	4.7 b	1.7 b	53.3 ab	16.0 a	125.6 b	93.3 b	201.3 b	71.0 b	130.3 c
Co-compost	17.7 b	0.0 b	52.0 ab	16.7 a	265.7 b	181.7 b	352.1 ab	68.7 b	283.4 b
Yard waste compost	8.0 b	5.0 ab	105.0 ab	48.3 a	237.3 b	180.0 b	403.6 ab	158.3 a	245.3 b
Control	10.7 b	4.0 b	111.7 a	49.0 a	296.7 b	216.7 b	472.1 ab	164.7 a	307.4 a
Cover crop removed	5.7 b	1.7 b	93.3 ab	43.3 a	210.0 b	161.7 b	354.0 ab	138.3 a	215.7 b
MC-33	52.0 a	0.0 b	5.0 c	0.0 a	545.7 b	490.0 a	602.7 a	5.0 c	597.7 a

[1] Plant-parasitic nematodes include *Helicotylenchus dihystera*, *Meloidogyne incognita*, *Pratylenchus neglectus*, *Quinisulcius acutus*, *Rotylenchulus reniformis* and *Tylenchus sandneri*, and non-plant-parasitic nematodes include Dorylaimids, *Mononchus* and Rhabditids.

[2] Data followed by same letters within a column represent insignificant differences at $P \leqslant 0.05$.

of high N content amendments. This might be the main reason that application of some low N content amendments, such as coal ash and yard waste compost, did not improve okra yields consistently. In addition, the significant increase in okra yield in treatments of sunn hemp combined with low N content soil amendments, such as coal ash, and yard waste compost, indicates that the N requirement by okra plants and that of the soil N balance can be adequately met by the organic amendments with high N contents, but not by those with low N contents because sunn hemp contains much more N than sorghum sudangrass, which can be contributed to okra plants. Therefore, to achieve high crop yields, soils amended with N-Viro soil, coal ash and yard waste compost must also be amended with additional N from another source. Furthermore, okra yields in the second year in most treatments were substantially higher than in the first year, which might be also related to the amount of N input into the soil because about 25% more cover crop biomass and N were produced in the second year than in the first (Fig. 1).

The results of root galling on okra plants from both years indicate that root-knot nematodes can be effectively suppressed by sunn hemp and biosolids. The coal ash treatment failed to suppress root-knot nematodes in the first year, but did so in the second. As a matter of fact, a number of researchers[3,29,50–52] have reported that *Crotalaria* spp., which include sunn hemp, suppress sedentary plant parasitic nematodes including root-knot nematodes, soybean cyst nematode (*Heterodera glycines*) and the reniform nematode as well as migratory nematodes such as sting (*Belonolaimus longicaudatus*), stubby root (*Paratrichodorus minor*), dagger (*Xiphinema americanum*) and burrowing (*Radopholus similis*) nematodes. The current experiment showed that sunn hemp combined with biosolids can suppress root-knot nematode populations almost as effectively as MC-33. The nematicidal action of MC-33 is nearly instantaneous, but that of the cover crop plus biosolids treatment is prolonged by the decomposition process, and growers might be able to schedule farm operations to take practical advantage of this approach in crop protection.

There have been several mechanisms reported on cover crops to suppress nematodes, such as acting as traps, which allow nematodes, especially the sedentary endoparasitic nematodes, to invade their roots but prevent completion of development within their roots[52], and favoring rhizosphere microflora that are strongly antagonistic to plant-parasitic nematodes[29,53]. However, nematicidal compounds in sunn hemp root exudates have been postulated to suppress root-knot nematodes[50,52,54]. The fact that removal of cover crop roots and shoots from the soil seemed to result in a higher population of root-knot nematodes, *M. incognita*, especially with and without sunn hemp, even though the difference was not significant (Tables 4 and 5), indicates that the decomposition of sunn hemp roots and foliar tissues after they were incorporated into the soil produces some impact on root-knot nematodes

Table 7. Soil electrical conductivity (EC) of 1 : 2 soil to water mixtures with cover crops and soil amendments in the first year experiment after okra harvest.

	Soil EC ($mS\,cm^{-1}$)[1]
Cover crops	
Sorghum sudangrass	1.399 a[2]
Sunn hemp	0.973 b
Fallow	0.885 b
Soil amendments	
Biosolids	1.021 a
N-Viro soil	1.376 a
Coal ash	1.171 a
Co-composts	1.204 a
YW-composts[3]	1.359 a
Control	1.280 a
Cover crop removed	1.051 a
MC-33	1.026 a

[1] The ratio of soil to water was 1 : 2.
[2] Data followed by same letters either for cover crops or for soil amendments represent insignificant differences at $P \leqslant 0.05$.
[3] YW, yard waste.

to protect the following crop. Of special importance is the suppression by sunn hemp of root-knot nematodes (*M. incognita*), since they are highly damaging to okra roots. Also it is important to note that sunn hemp either favored or at least did not suppress the build up in density of *Aphelenchus avenae*, Dorylaimids and Rhabditids, which are non-parasitic nematodes.

After the fallow treatment, all of the nematode taxa had decreased to non-detectable levels with the exception of the Rhabditids, which also had declined probably because in the fallow there was no plant to provide nutrition for the reproduction of those nematodes. Thus, growing sunn hemp or keeping the land fallow can effectively suppress root-knot nematodes, which shows the importance of this in the vegetable production of okra, one of the very nematode-susceptible crops in the tropical and subtropical regions. The same effect of treatments with MC-33 and biosolids on the suppression of root-knot nematode shows that both MC-33 and biosolids can effectively control the population of root-knot nematodes, *M. incognita*. The reduction of root-knot nematode population with sunn hemp rather than with sorghum sudangrass implies that the parasitic nematode-resistant cover crop, sunn hemp, may release some nematicidal compounds during the decomposition process to impact the reproduction of root-knot nematodes.

The increase in *Aphelenchus avenae* nematode by growing sunn hemp rather than sorghum sudangrass indicates that sunn hemp may facilitate the development and reproduction of the mycophagous nematode, *Aphelenchus avenae*, which helps to control some *Rhizoctonia* and *Fusarium* root-rot fungi[29,55].

The mechanism whereby biosolids combined with the incorporation of the root-knot nematode-resistant cover crop, sunn hemp, suppress root-knot nematodes is not quite

clear, but it might be related to the plant growth and development. Biosolids application induced okra plants to grow more vigorously than other treatments, which resulted in a great biomass and higher yields. Vigorous plants are often less vulnerable to attack by pests and pathogens than poorly developed or weakened plants[56,57]. A high content of ammonia in biosolids might result in the plasmolysis of nematodes and the proliferation of nematophagous fungi[58,59]. In addition, a high electrical conductivity (EC), i.e., 16.1 mS cm^{-1} (Table 1), in biosolids might play a vital role to control those nematodes. However, after okra harvest, there was no significant difference observed in soil EC under treatments with all soil amendments, but, for cover crops, soil EC in the treatment of sorghum sudangrass was significantly higher than that of either sunn hemp or fallow (Table 7). This result implies that rather complex mechanisms might be involved for cover crops or soil amendments in controlling plant-parasitic nematodes, which definitely need further investigation. Coal ash suppressed plant-parasitic nematodes somewhat, possibly because it has a high pH, i.e. about 12 in this experiment (Table 1), and the high pH may result in increasing the mortality of some parasitic nematodes[60,61]. Javed et al.[58] also found that the frequency of spore attachment of *Pasteuria penetrans* to *Meloidogyne javanica* increased with increasing the soil pH, e.g., the number of spores attached was significantly higher at pH 9 versus pH 7 or 5, i.e., 6.28, 5.44 and 1.00, respectively. However, we can conclude that growing and incorporating the nematode-resistant cover crop, sunn hemp, versus the conventional one, sorghum sudangrass, in the tropical or subtropical region, combined with some organic amendments, e.g., biosolids, can effectively improve okra production and suppress the root-knot nematode, *M. incognita*, which shows a promising potential to improve the organic farming and sustainable agriculture systems in the tropical and subtropical regions.

Acknowledgements. The project was financially supported by CSREES, USDA (Project Award No. 2001-51102-11325), USDA–CSREES–SARE, Project LS03–148, and the Florida Agricultural Experiment Station.

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Renewable Agriculture and Food Systems: 22(1); 54–66 doi:10.1017/S1742170507001597

Consumer interactions and influences on farmers' market vendors

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Accepted 3 April 2006 **Research Paper**

Abstract

Consumers interact with each other and vendors on a social level at farmers' markets. Some consumer social interactions, such as enjoying the market, talking with farmers about seasonal products and making a trip to the market a family event, are significant and positive influences on spending at farmers' markets as identified through a survey of 216 shoppers at eight farmers' markets in Maine. Vendors at these markets were also surveyed, with 65 of the 81 vendors being farmers. Through direct farmer/consumer relations, farmers indicated a willingness to reduce chemical inputs to meet customer demands, suggesting that customer interaction has the potential to affect environmental quality. By examining the linkages between producers and consumers at a direct market—often embedded with a sense of local identity—there is the potential to better understand social interactions that can support the economic and environmental sustainability of local agriculture.

Key words: farmers' markets, local, marketing, open space, farm viability, embeddedness, cluster analysis

Introduction

Direct markets, including farmers' markets, have been increasing in sales volume, number of customers and the number of farmers that depend on this type of outlet throughout the 1990s and 2000s[1], as well as over a longer time span from the post-World War II era[2–4]. Ironically, these local markets have grown in the context of globalization, perhaps as consumers seek an identity to otherwise anonymous and geographically distant products[5–7]. The marketing for these local products, or products with characteristics of a specific place, differ from commodity goods because consumers who seek out these products are looking for attributes not found in globally produced commodity goods, such as higher quality (freshness, for food), authenticity and a sense of local community[1,6].

The development of local agricultural markets has the potential to add value to farm sales as supply chains are shortened, as well as the potential to generate social and environmental benefits for the community, such as agricultural open space, a public good that contributes to the scenic value of communities[8,9]. Likewise, farm business managers with a keen eye to the external benefits of their local production may be able to capitalize on the added value of marketing with local place identities[10–12].

Surveys of vendors and consumers at farmers' markets were developed to test the hypotheses that:

1. in direct market situations, consumers and producers exert influences on each other that may alter the kind of product offered and/or the agricultural practices used to provide a product;
2. farmers' markets are inherently social places with consumer decisions being affected by such motivations as wanting to help farmers and supporting agricultural open space; and
3. consumers can be sorted into meaningful groups to help explain their purchase behaviors.

These surveys were implemented during 2 weeks in August 2004 after being reviewed by staff in the Division of Market Production and Development at the Maine Department of Agriculture.

Farmers in this survey sample engage in different practices, production decisions and marketing approaches than other farmers, likely due in part to proximity to urban populations[4], generally being small and medium-sized farm operations[1], or having a desire to engage in entrepreneurial activities. Likewise, farmers' market consumers are also generally different from the typical produce consumer[13]. However, others have noted the economic significance[14] of these population subsets and their role in bridging urban–rural differences[15]. Future applications of these concepts in

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marketing should recognize that these different consumer groups have sophisticated attitudes concerning place, community and their personal identities and derive value from these interactions because of their of authenticity and personal relationships.

Literature Review and Background

Direct marketing and local production

Local markets offer producers that cannot compete effectively through economies of scale production an opportunity to compete by diversifying, differentiating their products, entering specialty or niche-markets, value-adding on farm and assuming a greater share of distribution costs internally[16]. However, institutional barriers within state governments and agricultural land grant universities, as well as farmer perceptions, that emphasize volume production may have to be overcome to shift agricultural production to maximize *value per acre* rather than yield per acre. Despite the institutional, cultural and infrastructural barriers (e.g., lack of access to rural value-adding businesses like butchers, packagers and creameries)[17], there has still been a trend in the emergence of local and regional food systems[5,14,18], indicating that there is an incentive for producers to enter local direct markets, the rate of which may be economically suboptimal if there are barriers to entry.

The challenge is for farmers to tap into that local demand by marketing to consumers 'who think there's nothing like eating a fresh egg, who like knowing where their food came from'[17]. Through the face-to-face interactions typical for direct markets, producers receive feedback on new products and develop personal connections with customers[16,19]. The link between place, product and purchase is salient to the goals of farmland preservation[20,21]. For example, in the United Kingdom, The Countryside Agency links consumer food purchases and rural tourism with land preservation through their 'Eat the View' promotion[11]. While food quality remains the most important motivator for consumer purchases, other attributes of the marketplace including food production method, a locally grown product and wanting to help farmers are important to consumers[22,23].

Farmers' markets are social places and offer a different type of shopping experience than supermarkets or other retail outlets[3,4]. Lyson et al.[24] describe this difference of shopping at farmers' markets:

> As bridges between the formal and informal sectors of the economy, they enable individual entrepreneurs and their families to contribute to the economic life of their local communities by providing goods and services that may not be readily available through formal mass markets. Thus, they embody what is unique and special about local communities and help to differentiate one community from another[24].

Payne echoes these values, that 'many farmers' markets also provide their customers with a unique shopping experience that is often lacking in today's fast-paced world'[1]. Likewise, social interaction at farmers' markets is perceived as being more festive, more friendly and personal than supermarkets[25].

Social embeddedness of economic interactions

Within farmers' markets, economic interactions coexist with social interactions through the context of community and place, making these exchanges socially and geographically embedded[18]. Granovetter[26] and Block[27] develop a theory of social embeddedness to enrich the understanding of neoclassical economics by indicating that social interactions, such as those through trust relationships, help rational actors to mitigate risk. Hinrichs[18] first applied social embeddedness to direct agricultural markets and Lyson et al.[24] have noted specifically of farmers' markets that:

> From a neoclassical standpoint, farmers' markets may not make good economic sense. From a community perspective, however, they can nurture local economic development, maintain diversity and quality in products, and provide opportunities for producers and consumers to come together to solidify bonds of local identity and solidarity[24].

Thus, the consumer is socially embedded with the interactions of the market vendors *and* physically embedded through the consumption of products identified with the local physical environment[28].

Warde's theory of communification is that in the context of globalization, consumers face a need for 're-embedding' themselves in a sense of belonging, communicated through place, identity and community[6]. Mobilizing symbolic values of food, place and identity using such elements as tradition, nostalgia and authenticity has the ability to convey identities of place directly to consumers through their purchases[7,29,30]. As such, identity of place and community can play a role in farmland preservation and environmental quality[31]. However, the outcomes of these interactions, in terms of land preservation, environmental quality and other tangential benefits, require guidance and involvement from the community[32].

Previous research

Previous surveys generally focus on identifying consumer characteristics and purchasing habits[13,33–39], with few relating consumer and vendor data simultaneously[25]. Only one identified survey had the explicit goal of studying the connection between customer perceptions, direct markets and open space, yet did not include data on direct market vendors[40]. Data from this research identify that some consumers believe that their purchases of local products contribute to agricultural open space (Table 1).

Table 1. Attitudes used for cluster analysis (left-hand side) and significance (right-hand side).

Significance of clusters determined by consumer attitudes (1, strongly disagree; 3, neutral; 5, strongly agree)						
	Average values			Clusters compared		
	Cluster 1 Lifestylers	Cluster 2 Seasonal Shoppers	Cluster 3 Utilitarians	1 to 2	2 to 3	1 to 3
Statement	$n = 151$	$n = 55$	$n = 5$	t	t	t
a. Price is the most influential factor when I make my purchases.	2.46	2.65	1.40	−1.3439	**2.2569****	**1.6754***
b. Shopping at the farmers' market is less convenient than shopping at a supermarket for me.	2.30	2.91	2.20	**−3.2971*****	1.0259	0.1059
c. Fresh products are the main reason I shop at the farmers' market.	4.72	4.29	2.00	**3.2282*****	**3.1549*****	**3.0357*****
d. The farmers' market has products that I can't find anywhere else.	4.08	3.98	2.20	0.6344	**2.5995*****	**1.9032***
e. Direct contact with the farmer is an important reason to shop at the farmers' market for me.	4.34	3.15	1.20	**7.6480*****	**3.4401****	**5.8017*****
f. My purchases can affect farmers' production decisions.	4.36	3.00	1.40	**6.2613*****	**1.9358****	**4.7004*****
g. Buying locally produced foods is important to me.	4.85	4.04	1.00	**7.9953*****	**3.8497*****	**8.5701*****
h. I believe that shopping at farmers' markets supports agricultural open space.	4.81	4.04	0.80	**5.6920*****	**4.0555*****	**11.1347*****
i. I believe that shopping at farmers' markets improves the local economy.	4.80	4.02	2.00	**5.8095*****	**2.7726*****	**3.1286*****
j. I enjoy shopping at the farmers' market.	4.85	4.58	1.80	**3.0728*****	**3.0023*****	**3.7864*****
k. How my food is produced is important to me.	4.87	4.02	0.80	**9.2047*****	**7.1768*****	**11.3473*****
l. Personal health or diet concerns influence my food purchases.	4.61	3.82	1.00	**6.0785*****	**3.5575*****	**8.0159*****
m. Food safety concerns influence my food purchases.	4.54	3.69	0.80	**6.4787*****	**11.1362*****	**10.3320*****
n. Purchasing foods grown without manmade chemicals is very important to me.	4.68	3.71	1.40	**7.4643*****	**2.8540*****	**5.2171*****
o. Buying local products is an effective way to help preserve Maine's rural landscape.	4.83	4.29	1.80	**6.3920*****	**2.6873*****	**3.7578*****

* t-statistic significant at $P < 0.1$.
** t-statistic significant at $P < 0.05$.
*** t-statistic significant at $P < 0.01$.

Of particular interest to this point is that Kezis et al.[33], another survey conducted in Maine, indicated that quality was a primary reason for shopping at the market and that the next most important reasons were to enjoy the market atmosphere and a desire to support local farmers. Manalo et al.[40], in a random telephone survey in New Hampshire, identified that 98% of respondents agreed that 'buying local produce is an effective way to keep New Hampshire farms viable'. Both studies suggest that consumers have an interest in connecting their local food purchases to farm viability.

Through Kezis et al.'s Orono, Maine consumer survey[33], Kuches et al.'s random mail survey in Deleware[22], Brooker et al.'s two farmers' market surveys in Tennessee[38,39], and Hughes and Mattson's Kansas consumer and vendor survey[25], social processes were identified as key components of farmers' markets. For example, consumers generally learn of markets most often through word of mouth recommendations[22,25,33,39]. Kezis et al.[33] noted that shoppers generally bring others with them; only two-fifths shop alone. Also, Hughes and Mattson[25] indicate that the personal nature of the consumer and producer interaction gives public recognition for the vendor's labor, satisfying both emotional and psychological needs, and contributes to a consumer's sense of belonging.

In order to better describe consumers, responses from surveyed consumers were segmented based upon self-identified values through cluster analysis, a technique used

in market research[41]. While not applied previously to an agricultural marketing study, others have used cluster analysis to better understand how consumers make trade-offs between car prices, dealer relationship, and accessory packages[42]; preferences for different types of food using Likert-scale attitudinal questions[43]; and for developing a new marketing approach for tourists who vacation in Canada's rural regions[44]. A potential shortcoming of this methodology is its reliance upon consumer attitudes and unobserved behaviors, however Odekerken-Schroder et al. indicated that results from their analysis were in line with observed behaviors[42].

Methods

Survey design and implementation

Surveys were designed with input of the Maine Department of Agriculture and a review of other implemented surveys[33,35,45,46] to gather information regarding the motivations and demographics of both customers and vendors of farmers' markets. Eight communities were selected as representative of both geographic location and farmers' market size. The locations included: the inland towns of Farmington, a small town with a University of Maine branch campus; Orono, home of the main University of Maine campus; Falmouth, a suburban community outside of Portland, and the coastal towns of Portland, Maine's largest city; Blue Hill, a small vacation town, Bar Harbor, located at the entrance to Acadia National Park; Camden, a quintessential regional service center; and Belfast, a small working port. Informal interviews with farmers, consumers, community members, non-governmental organizations, agricultural researchers at the University of Maine and North Carolina State University and government officials provided relevant background information. Vendor and consumer surveys were pre-tested at the Auburn, Maine farmers' market, and then revised before implementation. A second set of revisions was made to the vendor survey after implementation at the Farmington and Orono markets: data from the revised questions were kept separate throughout the analysis.

In order to solicit consumer respondents at the farmers' markets, a small card table was set up with the phrases 'Farmer market research', 'Fill out a 5 minute survey', and 'Help this student graduate' printed on paper to advertise the research. Also, the surveyor wore a T-shirt with 'Survey Team' on the front and 'Help this student graduate. Fill out a 5 minute survey,' on the back. A total of 216 consumers responded to the survey. Self-selection methods have the potential to introduce bias by attracting only people interested in the survey topic. In this case, this effect is considered negligible since people at the farmers' markets already support the market, as indicated by their presence.

Vendor surveys were distributed to all vendors, including non-farmers, with instructions to fill out the surveys when they had time between customers. A total of 65 farmers and 16 other vendors were surveyed, with one refusal.

Market segmentation

Cluster analysis is seen as an exploratory method of data analysis used to generate hypotheses about market segments[41] and though it relies on self-identified attitudes and preferences, predicted behaviors will generally, but not exactly, conform to observed consumer decisions[42,43]. An advantage of using cluster analysis is that grouping consumers by using attitudinal questions helps to explain *why* consumers shop at farmers' markets rather than *who* shops as identified through demographic data alone.

Consumers were segmented based on their responses to 15 attitudinal Likert scale questions (see Table 1 for values and exact question wording). Ward's method of hierarchical analysis assumes that individual responses are independent and do not overlap (i.e., one consumer's response is not predicated by another consumer's response)[41]. This method compares the similarity of responses between individual consumer attitudes (represented in rows of data) by computing the average distance or linkage between values. Each row begins as its own 'cluster', and responses are grouped together until they are all in one cluster: the cut-off point for group selection is arbitrary[41]. However, following a logical procedure and applying statistics to back-check the difference between each cluster, the validity of these groups can be established[47]. The dendrogram in Figure 1 is a visual illustration of the process, conducted by using SAS 9.1.

No one method has yet emerged as a standard to determine the statistical relevance of these groups with various researchers using K-means clustering[43], MANOVA[42] and chi-square[44]. Cut-off groupings of five, four and three were developed. The three cluster grouping had the greatest statistical significance as identified by *t*-tests on the means for each of the 15 Likert question values, compared 1 to 2, 1 to 3 and 2 to 3. The other consumer responses were then added back into the dataset to allow for a more robust description of each group (Table 2), similar to the way Carmichael and Smith[44] added their consumers' demographics after clustering on 'lifestyle' values.

For convenience, each consumer segment was named based on characteristics of the three clusters, comprised of a total of 211 consumers. Cluster 1 is the largest group, representing 72% of the total survey population. These consumers have the highest levels of concern about factors external to food production, show an interest in visiting farms, talk with vendors the most and have the greatest diversity in their purchases, and thus are called the 'Lifestylers'. Cluster 2 represents 26% of the survey population and is most concerned about food quality and less concerned about external factors. Because consumers in Cluster 2 tend to purchase mostly fruits, vegetables and flowers but few other goods, this group is termed the 'Seasonal Shoppers'. Despite only having five

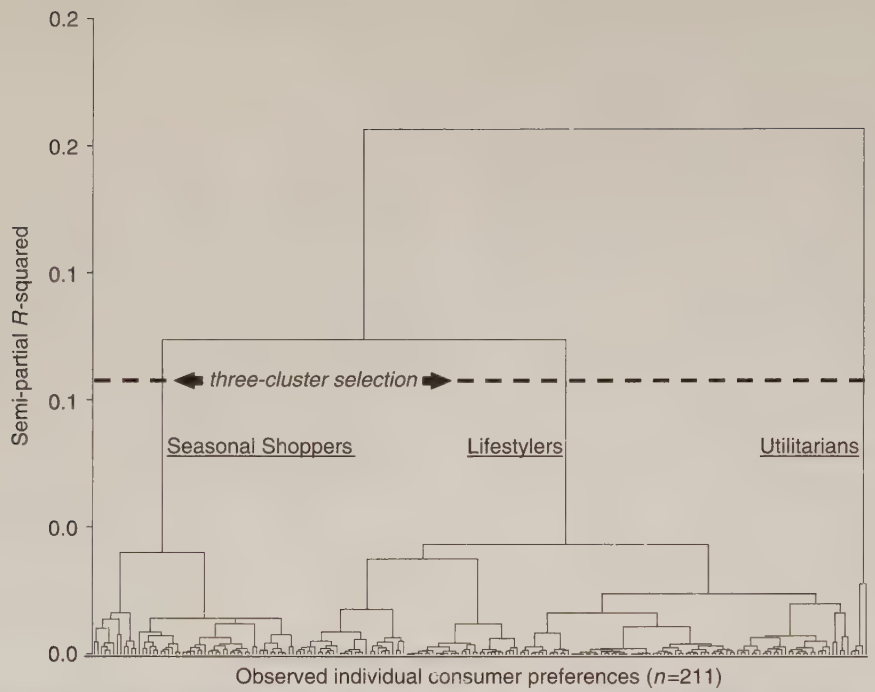

Figure 1. Cluster dendrogram. Dashed line represents where the three-cluster selection was made. The branch at the left represents the Seasonal Shoppers, the middle branch represents the Lifestylers, and the far right branch represents the Utilitarians. Each individual vertical line at the *x*-axis represents one individual's preferences, with the horizontal lines representing the groupings of similarities between preferences.

Table 2. Selected consumer cluster characteristics.

	Cluster descriptions		
Cluster Name	**Cluster 1 'Lifestylers'**	**Cluster 2 'Seasonal Shoppers'**	**Cluster 3 'Utilitarians'**
Cluster size (*n*)	**151**	**55**	**5**
Descriptive characteristics			
Miles from market	8.65	5.65	3.20
Age (average)	47.26	52.55	67.60
Household size (average)	2.66	2.33	1.80
Children under 18	34%	22%	20%
Income (average)	$74,169	$89,531	$83,500
Attitudes			
Chemical concerns	95%	58%	0%
Contact with farmer important	85%	36%	0%
Quality most important	51%	74%	25%
Organic most important	30%	17%	33%
Help farmer most important	30%	14%	33%
Market not convenient	19%	36%	20%
Behavior			
Would visit farm	83%	65%	60%
Visited farm	52%	35%	60%
Market a family event	62%	47%	80%
Spending per visit	$24.42	$20.47	$23.00
Purchases			
Vegetables	94%	89%	100%
Fruits	83%	80%	80%
Flowers/plants	59%	45%	60%
Dairy	40%	25%	20%

respondents (2.5% of the survey population), Cluster 3 remains statistically different with marked differences in attitudes concerning external factors to food. With no respondents concerned about synthetic chemicals or desiring contact with farmers, and a focus on high food quality, consumers in Cluster 3 are called 'Utilitarians'. It should also be noted that of the three groups, this was the cluster least interested in the social aspects of the markets, which may have also played a role in their self-selection decision to complete a survey.

Statistical analysis

Multiple regression analysis was performed on the dependent variables of farmer household income and consumer spending to identify significant influences on these variables. A binary choice probit model identified significant influences on consumers meeting someone they know at the farmers' markets. Correlations were used to identify the relationships between farmers changing their products to meet consumer demand. These analyses were performed using STATA Intercooled 8.2. Throughout the data, distributional tests including *t*-tests, Pearson's chi square and the Kolmogorov–Smirnov test (notated by D statistic) were applied. SPlus 6.2 was used to perform these distributional tests.

Results

Vendor and consumer profiles

Of the 81 vendors, 65 identified themselves as farmers with the remaining 16 being bakers, artisans, crafters, etc. Where relevant and when comparable data are available, farmer responses are separated as a subset of all vendor responses.

The surveyed farmers differed from the demographics of other farmers by age and education. The surveyed farmers' age distribution was skewed significantly ($P = 0.0002$, $D = 1$) towards the younger age groups and had a mean of 44 compared to a mean of 54 for Maine farmers[48]. Surveyed farmers also reported higher levels of educational attainment with 53% of market farmers completing 4-year degrees compared to 19% of other farmers in the Northern Crescent region[49].

Vendors indicated that their most important motivations to sell at a farmers' market were to have a direct relationship with customers (62%), more profit at farmers' markets (36%), independence and control of their business (27%), and 'other' (27%) of which promotion and proximity of the market to their farm were the most frequent responses. No attempt was made to identify whether the desire to have a direct relationship with customers was primarily for social or economic motivations, or both.

Surveyed consumers differed significantly from the Maine population[50] by education, income and gender. Surveyed respondents had significantly higher levels of educational attainment ($D = 0.7$, $P = 0.0123$), with three-fifths (60%) of respondents having earned a bachelor's degree or a graduate/professional degree compared to a quarter of Maine residents. Similarly, the respondent income distribution was skewed significantly to the higher end ($D = 1$, $P < 0.001$) compared to the Maine population. While all income ranges were represented, the mean respondent household income was approximately $70,000 compared to approximately $45,000 for the Maine population. A greater proportion of respondents were female, about three-quarters (74%) compared to half (51%) of the Maine population; however, this result is consistent with Kezis et al.'s Orono, Maine survey[33].

Consumers ranked freshness as the most important reason to shop at a farmers' market out of eight possible choices. Quality, availability of specialty products, helping the farmer and farmer contact were the next most important reasons and were statistically greater for the Lifestyler cluster compared to the Seasonal Shoppers, using a *t*-test ($P > 0.05$ for each reason). Price was consistently the lowest or next to lowest reason to shop at the markets. Respondents were also asked in an open response format to list three words or phrases that explained why they shop at farmers' markets. More than half of the responses (57%) were factors that related to the intrinsic quality of the food (e.g. freshness, local, quality and organic), while social interaction and market qualities made up about two-fifths (43%) of responses (e.g. atmosphere, fun, friendly and support farmers).

Social interactions

Social factors, such as having fun at the market and interacting with farmers, are important aspects of shopping at farmers' markets. Nearly all respondents (98%) had fun at the farmers' markets. More than half of the survey respondents (59%) make the farmers' market a family event. Also about half of respondents (48%) indicated that they had visited a farm from where they had bought products, while four-fifths (82%) would like to do so. Lifestylers had statistically higher preferences for visiting farms ($P < 0.01$), had visited farms more often ($P < 0.1$) and interacted with vendors more ($P < 0.001$) when compared to Seasonal Shoppers (Table 2). Topics of conversation with farmers differed significantly across clusters, with Lifestylers being the most interactive (Table 3).

Word of mouth was an important method for people learning about established markets (in general, surveyed markets advertised infrequently, if at all). More than two-fifths of consumers (45%) found out about the markets by word of mouth and a third (32%) learned of the markets from roadside signs or driving by the market. However, for the newest market in the survey, the Falmouth market, word of mouth was responsible for only a small percentage (6%) of how people found out about the market, with driving by (38%), roadside signs (13%) and publications (13%) being more important factors.

Most consumers (94%) talk with vendors and more than four-fifths of consumers (81%) meet people they know at

Table 3. Meeting familiar people and topics of discussion with vendors.

Behavior	Lifestylers $n = 151$	Seasonal Shoppers $n = 55$	Utilitarians $n = 5$
Meet people you know	83%	78%	80%
Talk with vendors*	98%	85%	80%
Topics			
Friendly gossip	67%	56%	60%
Seasonality	58%	35%	20%
Production methods*	55%	36%	40%
Preparation advice	51%	31%	0%
Freshness	48%	33%	20%
Sampling products*	44%	33%	60%
Price	28%	20%	20%
Other	13%	9%	0%

Distribution of discussion topics for all clusters differ significantly at $P < 0.01$ using the Kolomogorov–Smirnov test: Lifestylers/Seasonal Shoppers $D = 0.875$, $P = 0.0025$; $D = 1$, $P = 0.0002$; Lifestylers/Utilitarians $D = 1$, $P = 0.0002$; and Seasonal Shoppers/Utilitarians $D = 1$, $P = 0.0002$.
* Significantly different between Lifestylers and Seasonal Shoppers: talk with vendors $t = 2.338$, $P < 0.05$; production methods $t = 1.545$, $P < 0.15$; and sampling products $t = 1.900$, $P < 0.1$.

the market, other than vendors (Table 3). A binary choice probit regression model was used to identify factors that influence a consumer meeting someone she knows at the farmers' market (Table 4). Being a permanent state resident (a dummy variable), an increase in monthly shopping frequency, an increase in age and an increase in household size have positive effects on meeting someone a consumer knows at the market. Significant negative influences are an increase in the distance from home to the farmers' market and an increase in the region size which the respondent considered local.

Both consumers and vendors identified Maine, or the state level, as the largest region which they consider local. About two-fifths of consumers (39%) and half of vendors (54%) chose the state level (Maine) as the largest region they would consider food to be 'locally produced'. More than four-fifths of farmers (84%) identify their products as being local and three-fifths (60%) of farmers indicate that this is one of their main selling points (definitions of 'local' may differ by each market's bylaws).

Nearly all market farmers (95%) feel more involved with the community since they began selling at the farmers' market. Interaction with customers was the greatest source of this interaction (91%). More than half (58%) found that the interaction improved their overall product visibility. Two-fifths of farmers (41%) changed their products due to consumer demand, demonstrating that there is direct customer feedback for farmers. However, less than half of farmers (38%) felt that the community was supportive of providing the market location, often a public space or privately owned parking lot.

Economic implications

Market farmers had a median annual household income of $42,500 (the survey household income question was patterned after the US Census household income question), which was greater than those reported for Maine by the 2000 US Census (Table 5)[50]. Census data reported at the state level, the smallest geographic unit available for household income by occupation, were reported only as a median, so a statistical comparison could not be performed[51]. Compared with national data, market farmers had household incomes at least as high and generally higher than other farmers nationally (Fig. 2)[52]; however, these differences were not statistically significant, likely due to the variation within the relatively small sample ($n = 48$, 35% non-response rate). Farmer and farm manager income levels both are reported since surveyed farmers were not separated by these occupational distinctions. The data suggest that the sub-set of market farmers have higher incomes than other farmers, perhaps related to their higher levels of education (see Table 5) or as a result of more

Table 4. Probit model results of influences on consumers meeting others they know.

Variable	Change in probability of meeting someone: Permanent	Not permanent	Mean
Effect of being a permanent resident	22%	–	72%
Change in household size from 1 to 2	59%	34%	2.6
Change in household size from 2 to 3	64%	38%	
Change in age from 20 to 49	42%	16%	49
Change in age from 49 to 70	65%	32%	
Trips to market from once a month to once a week[1]	57%	31%	3.4
Distance from home to market from 0 to 10 miles	−3%	−7%	7.6
Distance from home to market from 0 to 20 miles	−19%	−14%	
Change in perception of local from County to State	−27%	−7%	State

$n = 210$.
All values significant at $P = 0.050$ except [1] which is significant at $P = 0.056$.
Wald chi-square 25.32, $P = 0.0003$.

Table 5. Comparison of market farmer and Maine farm household income.

Occupation category	All workers			Full-time workers only		
	Workers (total)	Median income	College graduates	Full-time workers	Median income	College graduates
Farm, ranch and other agricultural managers[1]	1065	$26,579	21.9%	795	28,981	24.6%
Farmers and ranchers[1]	2135	$10,995	18.0%	1225	17,067	17.4%
Survey sample	48	$42,500	63.6%	35	42,500	66.7%

[1] As classified by the US Census Bureau (1999 data).

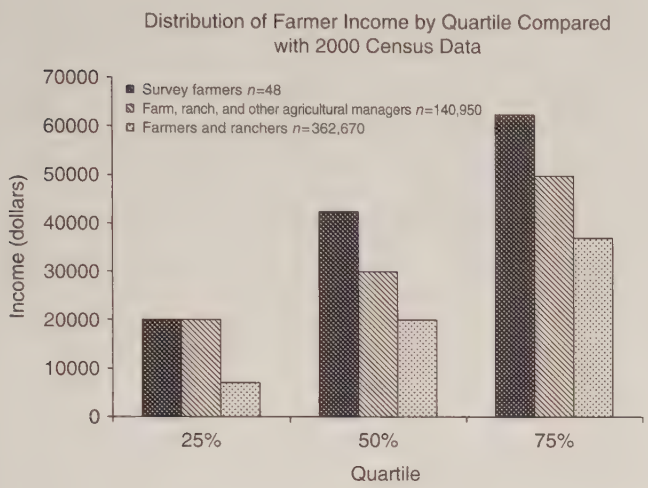

Figure 2. Market farmer income compared with other farmers nationally. Distribution of farmers' market farmers not statistically different from farm managers ($D = 0.3333$, $P = 1$) and farmers ($D = 0.3333$, $P = 0.6$) using the Kolmogorov–Smirnov test.

market farmers being engaged in agriculture as a full-time occupation. The majority of these farmers indicated farming as their full-time occupation (68%) and a third (32%) indicated farming as a part-time occupation ($n = 63$). Three-fifths of market farmers (61%) worked more than 2000 hours a year (or 38.5 hours a week on average) compared to less than a third (31%) of farmers in the Northern Crescent region[49]. Only one farmer indicated in a personal comment that this was his second career. The age distribution of these farmers was skewed to the younger age ranges, which reduces the possibility for a majority of the market farmers to be drawing upon a pension or retirement benefits from a previous career.

Influences on producer income were modeled through regression analysis. The error distributions were found to be normal and unskewed, so error was assumed to be homoskedastic. The natural logarithm was applied to the dependent variable, income, which is in units of dollars. Effort, as represented by total hours worked per year, and experience, represented as number of years at the market, were important economic influences on farmer income. There were diminishing returns to total hours worked per year and years worked at the market, so a quadratic expression of those variables was included. [It should be noted that the variable (years at market)^2 is not significantly different from zero, although its effect is not positive. Again, this variation is likely attributable to the small sample size.] One product type proved to have an important impact on farmer income, selling nursery or floriculture products, though it is imperfectly collinear with years at the market (correlation coefficient of 0.21). This is likely due to sampling frame error associated with variations in the small sample size ($n = 39$); however, the performance of these factors generally conforms to economic theories of diminishing returns. Formally, these factors may be modeled as:

$$\ln(\text{farmer income}) = \alpha\,(\text{years at market}) + \beta\,(\text{years at market})^2 + \gamma\,(\text{hours per year}) + \delta\,(\text{hours per year})^2 + \rho\,(\text{product type: nursery/floriculture}) + \varepsilon$$

Each year at the market was found to increase farmer income by 7.6% with an effect of diminishing returns reducing income by 0.3% per each additional year squared at the market. Each additional 1000 hours worked significantly increased income by 66.5% but has an associated 13% negative effect because of diminishing returns for each additional unit of 1000 hours squared. The sale of nursery or floriculture products has a significantly positive effect of 44% (Table 6). Overall, the regression had an F-statistic of 3.868, a P-value of 0.00579, and an R-squared of 0.3205.

Nearly all farmers at the farmers' markets (97%) indicated that there were good future prospects at the market (Table 7). When asked about more specific, financial details in an open-ended format, the response rate decreased to 33 respondents. Nearly all (94%) of 33 farmer respondents indicated an increase in sales with an average increase of $21,300 and a median increase at $10,000. Three-quarters of farmer respondents (74%) indicated a positive change in their overall financial situation and a quarter (26%) stated that their financial situation stayed the same ($n = 43$). Few farmers (14%) indicated that their debt had increased since selling at the farmers' market. Approximately half saw no change in their debt level (47%) and a third (33%) did not have debts. During the survey administration, some farmers indicated that their debt levels

Table 6. Regression results of influences on market farmer income.

Variable	Value	Std Error	*t* value	*P* value
Intercept	9.3864	0.3794	24.7397	0.0000
Years at the market	0.0761	0.0549	1.3864	0.1731
(Years at the market)^2	−0.0024	0.0024	−0.9884	0.3287
Annual hours worked (thousands)	0.6650	0.2890	2.3070	0.0266
[Annual hours worked (thousands)]^2	−0.1297	0.0542	−2.3918	0.0214
Nursery/floriculture	0.4432	0.2240	1.9788	0.0546

$n = 39$.
Multiple R-squared: 0.3205.
F-statistic: 3.868, $P = 0.005798$.

Table 7. Prospects for farmers at the market.

Question	Very good	Good	Neutral	Bad	Average	Median
Future prospects at the farmers' market[1] $n = 61$	56%	41%	2%	2%	4.5	5
Likert scale questions	**Increased**	**Stayed the same**	**Decreased**	**No debt**		
Overall sales change since selling at farmers' market $n = 33$	94%	3%	3%	N/A	$21,300	$10,000
Overall finances change as a result of selling at the farmers' market[2] $n = 43$	74%	26%	0%	N/A	4.3	5.0
Debt change as a result of selling at the farmers' market[3] $n = 43$	14%	47%	7%	33%	1.9	2

[1] Likert scale question where 5 = very good, 4 = good, 3 = neutral, 2 = bad, and 1 = very bad.
[2] Likert scale question where 5 = improved, 4 = improved a little, 3 = neutral, 2 = a little worse, and 1 = worse.
[3] Likert scale question where 3 = increased, 2 = stayed the same, and 1 = decreased.

were not related specifically to the farmers' market but to purchases of farm vehicles and equipment.

Consumer spending at farmers' markets is affected by both economic and social considerations, as indicated in Table 8. This regression output explains nearly a third (31%) of the variation in consumer spending at the farmers' markets ($n = 212$). Consumer income, shopping frequency at the farmers' market, enjoying the market, talking with vendors about seasonal products (while this was the only significant discussion topic, it is interesting to note that even one discussion topic was significant, suggesting that talking with vendors has a role on influencing consumer spending) and the market being a family event are all positive influences on spending. While the marginal effect of a $10,000 increase in household income is an increase of spending by $1, enjoyment, talking about product seasonality with vendors and the market being a family event each have a greater marginal effect on spending than income alone. However, attitudes towards freshness have a strong negative influence. Some possible explanations could be that fresher products are important (as evidenced earlier) but may not be the ultimate factor in the buying decision, or that social interactions are better predictors of spending than the intrinsic quality of the food. The importance of these social aspects indicate that consumer spending decisions are socially embedded, which is consistent with research on social capital theory[53,54].

Table 8. Regression results of influences on consumer spending.

Variable	Value	Robust Std Error	*t* value	*P* value
Intercept	4.1398	6.5729	0.6300	0.5300
Income	0.0001	0.0000	4.7200	0.0000
Shopping frequency	1.5212	0.6809	2.2300	0.0270
Attitude.enjoy	4.1643	2.1048	1.9800	0.0490
Topics.seasonality	5.6976	2.2857	2.4900	0.0130
Family event	6.7854	2.0300	3.3300	0.0010
Attitude.freshness	−4.7839	2.5902	−1.8500	0.0660

$n = 212$.
Multiple R-squared: 0.3115.
F-statistic: 6.17, the P value is 0.0000.

Environmental indicators

Market farmers often use their production methods to add value to their products. The most frequently used value-added production methods, in decreasing order of use, are heirloom varieties (44%), low spray or low chemical use (36%), certified organic (34%), organic practices without organic certification (34%) and free-range animal production (31%). Practices such as using heirloom varieties have the potential to increase the genetic diversity of agricultural land[55]. Also, many of these processes have

Table 9. Correlations of farmers changing products to meet customer demand.

Variable	Changed	Env	Lowchem
Changed	1.0000	–	–
Lowchem	0.3242*	1.0000	–
Env	0.2787*	0.0662	1.0000

$n = 65$.
* Significant at a 95% confidence interval.

the potential to reduce environmental impacts from decreased synthetic inputs.

Customer feedback has a role in changing environmental quality by influencing farmer production practices. Applying fewer chemicals and using the environment as a selling point are correlated with farmers changing their products to meet consumer demand (Table 9). A third of farmers (32%) who practiced low chemical applications have also changed their products to meet consumer demand. About a quarter of farmers (27%) who use the environment as a selling point have changed products to meet consumer demands.

A majority of the farms included in the survey (78%) produce on less than 25 acres of land, two-fifths (39%) of which produce on less than 5 acres. However, these farmers own more land than what they produce on: half of farmers (53%) own farms less than 100 acres in size. A total of 1909 acres were in agricultural use by the surveyed farmers, which represents two-fifths (38%) of the land that they own. Their total land area owned is 4986 acres, likely with most of the non-agricultural land being forested, as 90% of Maine is forest cover[56,57]. If this ratio of land in non-agricultural use is consistent across the 65 farmers' markets in Maine, state-wide market farmers' land in non-agricultural use would consist of approximately 2% of Maine's land in farms—however, further research would be needed to identify the scale of farmer's markets' contribution to non-agricultural open space.

Discussion

Social interactions are an important aspect of farmers' markets and influence consumer spending and promote change in some farmers' production practices. The social interactions facilitate feedback that allows farmers to be responsive to consumer demands. However, by focusing their marketing efforts on freshness, locality and organic production, farmers have not made an overt connection to the consumer's desire to support a working rural landscape. For example, consumers rated their belief that the purchase of local products is an effective way to help preserve Maine's rural landscape only behind personal enjoyment of the market (Table 1). Fresh products, a desire to know how their food is produced and the beliefs that their purchases improve the local economy and support open space were the next highest-scoring attitudes. As providers of a scenic value which adds value to the property tax base and can

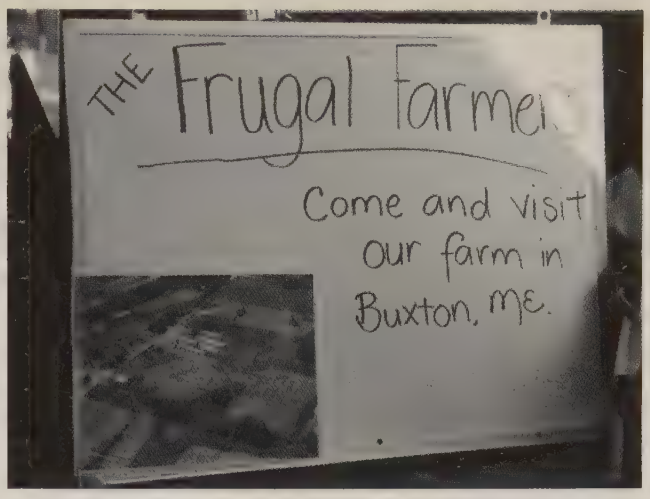

Figure 3. Vendor sign at the Portland, Maine farmers' market.

increase housing demand for a town[9], farmers could make a case to receive payment for their open space services, of which marketing their open space benefits to interested consumers is one mechanism. Farmers' markets, as one route for farmers to sell products directly to consumers, have already established this connection economically and socially (Fig. 3), and have the potential to do so environmentally (Table 9). Models exist for programs that certify farmer's scenic and environmental services through product labels that incorporate recognizable scenic landscape features, which often result in a price premium for labeled farm products[10–12,58].

While the environment was not identified as a primary purchasing motivator, aspects of certain production methods and practices including free-range and pasture-based methods have the potential for environmental benefits, though they may be marketed as linked to food quality. Future studies should aim to quantify the level of environmental literacy of farmers' market consumers and the relative importance of customer feedback compared with other influences that affect producer's practice adoption. To establish the potential contribution of social interactions to environmental quality, customer interactions and farm production methods would have to be tracked and evaluated over a period of time.

Conclusion

Compared to agricultural systems based on long supply chains, market farmers have the opportunity to interact directly with consumers and respond to shifts in demand as quickly as the agricultural cycle will allow. In so doing, the land managed by these farmers is under the control of a different set of market forces than land managed to be part of a production system of long supply chains. Economically, farmers in this survey indicated incomes higher than those for other farmers in Maine, and at least as high if not higher incomes than other farmers nationally. In addition,

there are social benefits and potential environmental benefits associated with selling in this type of direct market.

Social interactions at farmers' markets, such as the market being a family event and having fun at the market are commonplace, with social interactions contributing to consumer spending. The social atmosphere, friendliness of the markets and the ability for consumers to meet other people that they know indicate that community interactions are part of shopping at a farmers' market. Beyond being places of exchange between producers and consumers, farmers' markets are embedded within the context of communities. This emebeddedness allows consumers and producers to influence each other, most notably through producers responding to consumer demand for products with low chemical application and consumer spending being influenced by farmers talking with consumers about product seasonality.

Aside from social proximity, geographic proximity and locality are important contexts for farmers' markets, allowing consumers to identify visibly with the farmers as being part of the community and its physical landscape. Most of the surveyed farmers (85%) live within 50 miles of their markets. Producers and products are thus linked to place, the value of which is signaled to consumers through product freshness, conversations with the producer, and (some) production methods. The transparency and ease of information-flow in farmers' markets allows for consumer oversight of market farmer behaviors, which has the potential to provide positive landscape benefits instead of agricultural uses being perceived as local environmental hotspots[59].

Consumers respond to vendor signals in different ways and were able to be grouped according to their attitudes towards locally produced foods. By recognizing that consumers have different preferences—here characterized as Lifestylers, Seasonal Shoppers and Utilitarians through cluster analysis—farmers' market vendors have an opportunity to better understand *who* their consumers are and *why* they make their purchase decisions.

Consumers in this survey have indicated an interest in connecting their purchases with helping farmers, improving the rural economy, supporting their communities and supporting agricultural open space. Social interactions are a key component of farmers' markets, supporting information sharing between consumers and producers and fostering community interactions. Since the economic interactions are socially embedded, product and community identities are linked through these exchanges. Thus, the potential exists for social interactions to influence the adoption of practices with environmental benefits, promote community development and offer producers a unique, uncommodifiable identity of place with which to market their products.

Acknowledgements. I thank the Maine Department of Agriculture, Division of Market Production and Development for help in constructing the survey instruments; the Edna Bailey Sussman Foundation for a research grant; my advisor Randall Kramer, PhD, Professor of Resource and Environmental Economics, Duke University, for his support of and encouragement of this project; Jon Eisen-Hect, PhD, Duke University, for his technical expertise in analytical methods; Charles Becker, PhD, Duke University, for his advice on econometric modeling; and the farmers' market vendors of Auburn, Bar Harbor, Belfast, Blue Hill, Camden, Cumberland, Damariscotta, Farmington, Orono and Portland for their willingness to participate in this research.

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Renewable Agriculture and Food Systems: 22(1); 67–73 doi:10.1017/S1742170507001627

Farm woodlots in northern New England, USA: Characteristics, management, and contributions to the whole farm system

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Accepted 28 April 2006 **Research Paper**

Abstract

Farms and forests dominate the rural landscape of the northern New England states of Maine, New Hampshire and Vermont, among the most heavily forested states in the US. However, we know little about the stewardship of farm woodlots and their contributions to the whole farm system, despite region-wide increases in farm forest acreage. Using a mail survey, this study found that almost half of respondents had a written management plan for their forestland, most of which had been written by a forester, and approximately three-quarters took an active role in the management of their woodlots. Farm woodlot harvesting and management contributed over 7% of total farm income. Variables such as respondent's state of residence, age, education and type of farm were investigated in order to better understand farmers' forest stewardship behavior. Implications for effective outreach to farm forest owners are offered.

Key words: farm woodlot, farm forest, forest stewardship

Introduction

The states of northern New England are among the most heavily forested in the United States: Maine is the most heavily forested state in the country (90% of the state's total land area is forested), and the land areas of New Hampshire (84%), and Vermont (78%) are predominantly forested[1,2]. New Hampshire was the only state in northern New England in which the number of forestland owners and the amount of forest acreage have decreased during the period 1978–1994[3] (Table 1), and the amount of forestland area in that state appears to continue to erode, primarily due to development[2].

Farms often combine with forests to characterize the region's rural landscapes, especially in areas of more productive soils, and farm woodlots represent a significant forest resource. Farmers in the region own over 3 million acres of land, approximately 10% of the total land area in the region, and approximately 49% (1,492,227 acres) of the total farmland in the region is woodland[4]. While total farmland acreage in northern New England decreased between 1997 and 2002, farm woodland acreage in the region increased during the same period. The 2002 Census of Agriculture found that 47% of Maine's farm acreage is woodland, while 60% of New Hampshire's farm acreage and 42% of Vermont's farm acreage are woodland, an increase in all three states since the 1997 census. However, both the total number of farms and the number of farms with woodland decreased in all three states during the same period[4]. The amount of total farmland per farm and the amount of woodland per farm have remained virtually unchanged in Vermont between 1997 and 2002, while farms in Maine and New Hampshire have shown increases in both attributes during the same period. In addition, available data from Maine indicate that, for the total acreage enrolled in that state's current use assessment program for farmland in 2004, 53% of the total farmland was farm woodland, and the value of enrolled farm woodland was $58,135,96 versus $33,242,461 for enrolled agricultural land[5].

Despite their regional and local importance, the stewardship of farm woodlots has rarely been a primary focus of research on non-industrial private forests (NIPFs) in the US. This study was designed to characterize the stewardship behavior, including management and harvesting activity, on farm forests in northern New England, a forest ownership type that is increasing in size even as farmland acreage and the number of farms in the region are

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Table 1. Changes in the number of forest owners and amount of forest acreage in northern New England between 1978 and 1994 (from Birch[3]).

State	1978 number		1994 number	
	Owners (thousands)	Acres (millions)	Owners (thousands)	Acres (millions)
ME	241.4	15.698	255.6	17.060
NH	122.3	4.307	83.7	4.144
VT	53.3	3.926	80.5	3.993
Total	416.7	23.931	419.8	25.197

decreasing. Attributes related to forest stewardship, including the presence of a forest management plan, professional forester involvement in the execution of the plan and active landowner participation in forest management[6], were among the key attributes used to better understand farm forest management.

Moreover, this study attempted to understand the contributions of farm woodlots to farm economies and the sustainability of farm woodlots in the region. In addition to comparing forest ownership and management among farmers from the three states studied, this research also compares these attributes between dairy and non-dairy farmers, hypothesizing that dairy farmers are more engaged in farming activity as a full-time, year-round occupation and, therefore, may have less time to dedicate to farm woodlot management. The relevance of results to the future of farm woodlots and implications for effective outreach to farm woodlot owners are discussed.

Background

Previous studies of NIPFs have helped to develop baseline information for understanding private forest ownership in the northeast US. For example, Birch[3] found that approximately 42% of the private forest landowners in the northeast US owned forestland primarily because it was 'part of the farm' or 'residence'. These ownerships were generally smaller than 30 acres. An additional 10% of the landowners indicated that farm or domestic use (e.g., fence posts, fuel wood) was the most important reason for owning forestland. In Maine, approximately 25% of the state's forest is held either primarily or secondarily for farm or domestic use or because the land was part of the farm[3].

Although much of the scientific literature on NIPFs in the US up to 1995 has been summarized[7], most of these studies lump non-industrial and non-public forest ownership into the broad NIPF category, and there is little published research that has focused specifically on farm woodland ownership and management. Yet, as described by Moser et al.[8] in their recent study of farm forest management in three midwestern states, farm woodlands, in particular, are important 'islands of biodiversity in the agricultural landscape' (p. 1), and farmers are more likely than other NIPF owners to maintain a utilitarian view of forest ownership. Forty percent of farmers in their study cited 'part of the farm' as the primary reason for owning forestland. Other reasons included pasture (8%), enjoying the woods (8%), hunting (7%), and investment (5%). Approximately two-thirds of the 152 survey respondents indicated that they had conducted some form of timber harvesting during their ownership of the farm woodlot.

The environmental, social and economic importance of farm forests have also been discussed elsewhere. A conference focusing on *Farm Forests for the Future*, held in the UK in 1999, for example, identified gaps in information about farm woodlands there, including the quantification of the social, economic and environmental benefits of farm forests and the evaluation of the best approaches to providing appropriate outreach to farm forest owners[9,10]. In Germany, Brandl and Schanz[11] reported that 38% of the land associated with a network of farm enterprises in the state of Baden–Württemberg was forest. Brandl[12] found that forestry contributed approximately 28% to 'traditional' farm income among farm enterprises in the Southern Black Forest. Similar studies of the contributions of farm forests to the farm economy do not appear to exist in the forest science literature in the US.

Methods

A mail survey of farmers in northern New England was conducted. Since there is no comprehensive mailing list available for farmers in the region, lists of farmers were gathered from Departments of Agriculture in each of the three northern New England states who maintained lists of farmers for newsletter mailings. The combined list of farmers in the region contained 700 farmers from New Hampshire (11% of the total number of farmer contacts), 2738 from Maine (44%) and 2825 from Vermont (45%). Before conducting the survey, a test survey was mailed to a random sample of 100 farmers in the region in order to both refine the survey instrument and anticipate the response rate for the subsequent main survey. The main survey was then mailed to a random sample of 3000 farmers in the region using multiple mailings[13]: a survey mailing followed by a reminder postcard and then a final survey mailing to those who had not yet responded. The number of farmers receiving the survey in each state was proportional to the number of farmers from each state on our contact lists. As a result, 330 farmers from New Hampshire (11% of 3000) were mailed the survey, as were 1320 from Maine and 1350 from Vermont.

Appropriate linear and non-linear statistical analyses were performed, including analysis of variance (AOV), contingency table analysis and logistic regression analysis. For some analyses, data were also partitioned by state of residence of the respondent and the type of farm (i.e., dairy versus non-dairy) in order to both refine analyses and to detect differences in farm woodlot ownership and management among these subpopulations. Survey non-response bias was estimated by comparing survey responses of early

Table 2. Background information for farmers in northern New England, overall and by state. USDA National Agricultural Statistics Service (2002) estimates for age are reported after those found by this study. Standard errors for our estimates are in parentheses.

	Overall	ME	NH	VT
Age (years)	54.8	56.2/53.7	54.7/54.1	53.7/53.9
($F = 3.27$; $P = 0.04$)	(0.45)	(0.68)	(0.96)	(0.71)
Years farming	28.1	27.3	28.3	28.6
($F = 0.56$; $P = 0.57$)	(0.57)	(0.88)	(1.37)	(0.89)
Weeks farming per year	43.9	39.0	44.6	47.5
($F = 25.60$; $P < 0.01$)	(0.56)	(1.06)	(1.31)	(0.67)
Hours farming per week	49.3	38.3	50.3	57.3
($F = 31.36$; $P < 0.01$)	(1.14)	(1.66)	(2.70)	(1.69)
Years education	13.8	14.3	14.5	13.3
($F = 14.62$; $P < 0.01$)	(0.10)	(0.28)	(0.12)	(0.35)
Generations of farmers preceding respondents	2.2	2.3	1.8	2.3
($F = 1.56$; $P = 0.21$)	(0.09)	(0.16)	(0.22)	(0.17)
Type of farm (percent of respondents) ($\chi^2 = 122.42$; $P < 0.01$)				
Dairy	20	2	14	37
Non-dairy	80	46	16	37
Encourage son/daughter to farm (% YES) ($\chi^2 = 8.67$; $P = 0.07$)	37.9	37.7	47.4	34.9
Expect to farm in 5 years (% YES) ($\chi^2 = 18.58$; $P = < 0.01$)	61.3	66.8	71.1	53.8
Total farmland acres owned	220	259	161	209
($F = 5.04$; $P = 0.01$)	(10.9)	(24.8)	(19.7)	(9.7)
Enrolled in current use assessment for forested land (% YES) ($\chi^2 = 88.73$; $P < 0.01$)	57	37	96	62
Own at least 10 acres of forest (% YES) ($\chi^2 = 11.00$; $P < 0.01$)	77	84	72	74
Total farmland acres owned by those who own farm woodlots	266	303	215	249
($F = 54.58$; $P < 0.01$)	(13.4)	(29.0)	(24.7)	(11.3)
Forest acres owned by those who own forest	150	181	159	120
($F = 4.67$; $P = 0.01$)	(9.4)	(19.2)	(24.0)	(8.4)
Percent farm income from forest for those who own forest	7.4	6.4	6.8	8.3
($F = 0.69$; $P = 0.50$)	(0.8)	(1.1)	(2.1)	(1.2)

respondents with those of late respondents[14]. Analyses were conducted at alpha = 0.05.

Results

A total of 1101 farmers responded to the survey: 30 farmers responded to the test survey (response rate = 33%), and 1071 (approximately 36%) farmers responded to the main survey mailings. Non-response bias was not found when responses from early survey participants (those who had responded to the survey by January 31, the first month of the survey) were compared with those of late survey participants (those who had responded during the months of February and March, the final month of the survey), suggesting that farmers who completed and returned the survey were from the same population as those that did not[14]. For example, whether respondents indicated that they had a forest management plan ($\chi^2 = 0.06$; $P = 0.81$), were active forest managers ($\chi^2 = 0.95$; $P = 0.33$), or had harvested timber on their woodland ($\chi^2 = 1.79$; $P = 0.18$) was not dependent on whether they were early or late survey respondents.

Respondent background

The average age of respondents was approximately 55 years, while the average number of years of formal education was approximately 14 years (Table 2). Respondents had been farming an average of 28 years, and were preceded by over two generations of farmers. Over one-third would encourage a son or daughter to farm. The largest category of farmer-respondent was dairy farmer: approximately 20% of respondents who responded to the question *What type of farming do you do?* identified themselves as dairy farmers ($n = 150$), while the rest ($n = 588$) indicated that they were engaged in some other type of farming, such as field crops, sheep or poultry. This response depended on the state of residence of the respondent: approximately 86% of those respondents who identified themselves as dairy farmers were from Vermont.

Farmers in the region worked 44 weeks per year and 49 h per week, and these means were significantly different among states. For example, Vermont farmers worked more weeks per year and more hours per week than their counterparts in Maine and New Hampshire. These differences may be attributed to the proportion of dairy farmers among the general farming public in each state. While 37% of respondents from Vermont said that they were dairy farmers, less than 2% of Maine farmers and 14% of New Hampshire farmers identified themselves as dairy farmers. There was a significant difference between dairy and non-dairy farmers in the mean number of weeks that respondents engaged in farming per year ($F = 30.72$;

$P < 0.01$): dairy farmers worked an average of 50 weeks per year, while non-dairy farmers worked 42 weeks per year. In addition, dairy farmers reported working 73 h per week, while non-dairy farmers worked 43 h per week ($F = 138.58$; $P < 0.01$).

While approximately 60% of farmers in the region said that they intended to be farming in 5 years, just over half of the farmers in Vermont, the youngest group surveyed, indicated that they would be farming in 5 years. Overall in the region, farmers owned an average of 220 acres, although this estimate varied among the three states studied (Table 2). Mean farm acreage was not significantly different between dairy farms (241 acres) and non-dairy farms (217 acres) ($F = 0.77$; $P = 0.38$).

Farm woodlot ownership

Although there is some variability among respondents by state, over three-quarters of farmers in the region owned at least 10 acres of forestland (Table 2), agreeing with USDA estimates that showed that of the 17,130 farms in the region, 12,786 (75%) included woodlands as part of their overall farmland[4]. When partitioned by type of farm (dairy versus non-dairy), approximately 70% of dairy farmers said that they owned woodland, while 79% of respondents who indicated that they engaged in some other type of farming said that they owned woodland ($\chi^2 = 5.90$; $P = 0.02$). The average farm woodlot size in the region was 150 acres, with Maine farmers reporting the largest farm woodlots and Vermont farmers the smallest. There was no significant difference in farm forest size between dairy farm woodlots (126 acres) and non-dairy farm woodlots (155 acres) ($F = 1.44$; $P = 0.23$).

The enrollment of farm forest acreage in current use assessment programs designed specifically for forestland varied widely among the three states studied, from 96% of farm forest ownerships in New Hampshire to only 37% in Maine. In addition, enrollment in current use assessment was dependent on the type of farm: 68% of dairy farmers enrolled their farm woodland acreage, while 54% of non-dairy farmers did so ($\chi^2 = 6.58$; $P = 0.01$). However, it is not known from our data whether some Maine farmers, for example, had enrolled their farm and forest acreage together under the state's Farm and Open Space program instead of enrolling their forestland separately in the state's Tree Growth program[15].

Only 28 respondents indicated that they used to own forest as part of the farmland, but no longer did. Of these, six (21%) sold the forestland for development; nine (32%) sold the forestland 'as is'; seven (28%) passed the forestland on to heirs; and six (21%) described other reasons for no longer owning forestland (e.g., forest was cleared for a field or converted to pasture).

Over a third of respondents indicated that the primary reason for owning forestland was that it was part of the farm, while 10% indicated that the primary reason was investment. However, only 5% of Vermont farmers cited investment as a primary reason, while 15% of New Hampshire farmers cited investment. Farm/domestic use and timber were cited by 7% of respondents (Table 3). These results differ somewhat from those of Butler and Leatherberry[16], who surveyed 6352 family forest owners (both farmers and non-farmers) in the midwestern US. They found that the most common reasons for owning forestland were enjoyment of beauty and scenery, privacy, protection of nature and biological diversity. In contrast, aesthetics was cited by only 3% of farmers in our study.

Table 3. Primary reason for owning forestland according to farm woodlot owners in northern New England.

	Overall	ME	NH	VT
	(%)			
Part of the farm	35	32	38	37
Investment	10	12	15	5
Farm/domestic use	7	8	6	7
Timber	7	6	10	6
Aesthetics	3	2	2	3
Sugaring	2	1	0	4

Table 4. Responses from farm woodlot owners in northern New England to the question: *Which best characterizes your future plans for your forestland?*

	Overall	ME	NH	VT
	(%)			
Continue owning	49	49	43	51
Pass down to heirs	39	40	48	36
Sell as is	4	4	3	4
Harvest, then sell	3	3	3	2
Subdivide	2	2	2	1
Other (includes: sugaring, clearing for fields/pasture, harvest, conservation, sell with the farm, unsure) ($\chi^2 = 6.993$; $P = 0.73$)	4	2	2	6

Approximately half of the respondents indicated that they intended to continue owning their farm woodland, while 39% said that would pass the woodland to their heirs. Four percent or fewer indicated that they would sell their woodland as is, harvest and then sell, or subdivide their forestland (Table 4). There appeared to be no association between farmers' future plans for the woodlots and their state of residence.

Farm woodlot management

Almost half of the respondents in this study said that they had a written management plan for their forestland, most of which had been written by a forester (Table 5). In addition, approximately three-quarters took an active role in the management of their woodlots, and 84% said that they had harvested timber on their land (Table 6). Again, there are

Table 5. Forest management activity engaged in by farm woodlot owners in northern New England.

	Overall	ME	NH	VT
	(%)			
Written management plan (% YES) ($\chi^2 = 3.95$; $P = 0.14$)	47	42	49	51
Plan written by a forester ($\chi^2 = 6.943$; $P = 0.049$)	93	92	83	96
Farmer takes an active role in forest management ($\chi^2 = 2.57$; $P = 0.28$)	73	70	69	76

Table 6. Forest harvesting behavior of farm woodlot owners in northern New England.

	Overall	ME	NH	VT
	(%)			
Have you harvested your woodlot (% YES) ($\chi^2 = 0.21$; $P = 0.90$)	84	84	83	85
Who designated trees for harvest? ($\chi^2 = 31.24$; $P < 0.01$)				
Landowner	48	43	24	59
Forester	34	31	63	29
Logger	17	25	13	12
How were trees designated for harvest? ($\chi^2 = 26.34$; $P < 0.01$)				
Marked by forester	20	15	41	17
No marking by a forester (includes land clearing, ice damage salvage)	55	58	48	56
Diameter limit	14	12	10	16
Species	11	15	2	11
Who harvested timber? ($\chi^2 = 22.02$; $P < 0.01$)				
Landowner	38	33	19	47
Logger	36	36	52	30
Landowner + logger	26	31	29	22
Equipment used when landowner logs				
Farm tractor	87	79	87	93
Skidder	6	10	6	4
Animals	2	2	6	1
Other, including dozer, ATV, pick-up truck	5	9	0	1

differences between these results and those of a recent study conducted by Butler and Leatherberry[16], who found that among NIPF owners in the midwestern US whom they surveyed, 27% had harvested in the past 5 years, 4% had written management plans, and 13% had sought management advice. Of the respondent background variables studied, logistic regression analysis found that respondents' education ($P < 0.01$) was associated with whether they had a written forest management plan, while age and years of farming experience were not significant variables. Respondents with management plans had a mean education of 14.6 years; those who did not have a plan had a mean education of 13.4 years. In addition, education was the only one of the three variables that was associated with whether the respondent was an active forest manager ($P < 0.01$), although age ($P = 0.06$) and years farming ($P = 0.06$) were 'near' significant. Again, farmers with more education (14.2 years versus 13.5 years) were associated with being active forest managers.

Respondents who said that they were active forest managers reported spending an average of 134 h per year in the management of their forest, while those who said that they were not active forest managers spent an average of 14 h per year in the management of their forest ($F = 24.21$; $P < 0.01$). Cutting firewood was the most often reported type of forest management activity. Although non-dairy farmers spent more time each year managing their woodlot (106 h) than did dairy farmers (66 h), this difference was not statistically significant ($F = 1.80$; $P = 0.18$). However, responses to the question *Do you take an active part in the management and/or harvesting of your forestland*? were dependent on whether the respondent was a dairy farmer or not, with 76% of non-dairy farmer responding *yes* and 62% of dairy farmers responding *yes* ($\chi^2 = 9.13$; $P < 0.01$).

Farmers designated trees for harvest in almost half the cases studied, and engaged a forester for this activity in approximately one-third of the cases. When a forester was not involved in the marking of timber, harvests often took the form of land clearing, salvage, species removal, or some form of diameter limit harvest (Table 6). New Hampshire farmers reported with greater frequency than farmers from Maine and Vermont that they engaged both a forester to mark their timber and a logger to harvest their timber.

In over half of the cases in this study, farmers either did the logging alone or in combination with a logger (Table 6). When logging themselves, farmers generally used a farm tractor to yard harvested wood. When asked how they learned to log, half the farmers responded that relatives

contributed to their knowledge of logging skills, while 31% said that they were self-taught. Some (7%) said that a logger taught them, while the rest indicated that there were several things that contributed to their knowledge of logging, including friends, neighbors, courses, extension publications and books.

In addition, farm woodlots contributed over 7% of total farm income for farmers who owned forestland. However, those respondents who indicated that they were dairy farmers reported a contribution to the farm economy from woodlot management of less than 3%, while those who said that they were not dairy farmers reported a contribution of slightly more than 8% ($F = 7.48$; $P < 0.01$).

Conclusions and Implications

Differences in reported forest ownership objectives and forest stewardship behavior between farm woodlot owners in northern New England and the broader NIPF owning public suggest the need for focused outreach efforts. The reasons for forest ownership cited by farmers may be quite different from those cited by other NIPF owners, and the uses of farm woodlots may be quite different from those of other NIPFs. Outreach programs aimed at the sustainability of NIPFs, including those related to the education of forest owners and the subsidization of their forestry activity, may benefit from more targeted efforts that recognize the diversity and specific needs of subpopulations of the forest owning public, including farmers. For example, a DVD and fact sheet have been developed from this research and distributed to outreach professionals in northern New England to provide them with additional tools for focusing their efforts on farm forest owners. The messages developed and delivered by the DVD, for example, suggest that farm forest stewardship involves developing a forest management plan and hiring a professional forester to help execute the plan. While these messages are not new in outreach efforts to NIPF owners generally, the DVD summarizes data from research that is specific to farm forest management and involves on-camera interviews of farmers, perhaps helping the farmer-recipient of the information better identify with the messages being conveyed.

The proportion of farmers in northern New England who have indicated that they have management plans for their woodlot that have been written by a forester may be encouraging when these results are compared with those from other studies of NIPF owners[16,17]. However, the number of farmers directly engaged in designating trees for harvest and firewood and timber removal, coupled with an apparent lack of formal training in these areas, suggests an outreach need focusing on harvesting and silviculture education for many of the region's farmers. The quality of the stewardship on farm woodlots versus other NIPFs, as well as the stewardship of dairy farm forests versus that on woodlots associated with other types of farming is not known from this study and may be a fruitful direction for future field and social science research.

That approximately 7% of total farm income in the region derives from some form of farm woodlot management raises questions about the significance of the farm forest to the farm economy, particularly for non-dairy farmers. Is 7% a significant proportion of income for farms in the region? In addition, the precise nature and disposition of this forest-generated income requires further elaboration in order to better understand the monetary contributions of farm woodlots to farm economies. However, since recent census data have shown that the amount of farm woodlot acreage in the region is increasing while both total farmland and the number of farms is decreasing, one might anticipate that, for those remaining farmers who own forestland, the potential contribution of farm woodlot management to the farm economy will increase. Dairy farmers who own woodland appear to be less active forest managers and derive a smaller proportion of their total farm income from farm woodlot management. This is likely due, in part, to the full-time, year-round nature of dairy farm work compared to the work associated with many other farm systems.

Land use conversions, including those related to urbanization and exurbanization[18], suggest challenges to maintaining working farms and farm forests in the region. Farmland in the region may be particularly vulnerable since it generally occupies the most productive land, which in many cases is also the most accessible and developable land. This phenomenon appears to be particularly acute in New Hampshire, where forestland and 'high quality' farmland are being rapidly developed[2]. Perhaps consistent with this, our study showed that while only 5% of Vermont farmers cited investment as a primary reason, 15% of New Hampshire farmers cited investment. However, this study also found that approximately 88% of farmers who own woodland intended to either continue owning it or pass it to heirs. The degree to which this translates to behavior and the intentions of heirs is not known.

Acknowledgements. The author wishes to acknowledge Jennifer Brickey for her help with data collection and management, as well as the Associate Editor and two anonymous reviewers for their valuable input.

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Renewable Agriculture and Food Systems: 22(1); 74–76

Book Reviews

The Fate of Family Farming: Variations on an American Idea. By Ronald Jager. 2004. University Press of New England, Hanover and London. 268 p. $26.00, ISBN 1-58465-026-5, cloth cover.

Anyone who reads this review in this journal would enjoy reading this book. You already read a lot of writing on farming and alternative farming and the harsh things nature and civilization continually threaten farming with. And this book has those things in it. But the arrangements are fresh. There's pleasure taken in the composition and in its aphoristic triumphs: 'It was summertime in New England, and the sheep were in the meadow. ... A pesticide is a rigorous device for developing insects immune to it. ... No one brings a plow to paradise.'

One reason for this is that the author does not pretend to read a lot in the professional and academic literature of alternative and family farming. He can title a chapter 'Four Farms', which discusses the clever practices of four different farms at various points on a spectrum from alternative to industrial, without any reference to Mark Kramer's classic study *Three Farms*. Jager is a retired professor of philosophy from Yale who wrote precisely and imaginatively in his own field. But he's retired to rural New Hampshire where he admires his rural, farming neighbors for their hard work and success and for their reminding him of his own rural upbringing. He wonders at considerable length about the process he's observed in his own lifetime of the ubiquitous farming of his youth becoming the rare family farming of the present. He reads enough in the literature about such questions that he finds useful. He has much more in the book that he draws from interviews with and observations of how his neighbors are actually doing.

The gist of the book, its most original idea at least to me, was that family farming in the sense of resolutely wholesome farming has almost always been subversive to the dominant economic paradigms of the day. Those paradigms demand eventual industrial productivity out of farms as out of factories or schools. But someplace in their evolution from subsistence, cottage or craft activities, farming and crafting and learning go through a necessary economic evolutionary period where the work is done well, at home, with natural materials, primarily for the benefit of those living nearby and making a living directly off the enterprise. It's a wonderful, ideal phase soon pushed aside for something more robust and abstract and amenable to social planning. The Roman latifundia or 'big spreads' drove out the yeomen farming beloved of Virgil and Cicero just as American factory farms drove out the yeomen family farming beloved of Crevecoueur and Wendell Berry. But never completely, since there are always enough farmers perverse and clever enough to figure out how to eddy against the current of the Big Flows. Clever farmers today offer organic produce and gently raised livestock to people alarmed about the miserable nutrition and even poisonous qualities of chemical farming and mass slaughterhouses. Some of these farmers actually get good enough at marketing to make serious money at the business, although never from following a formula. It's hard to teach subversive farming in regular academic curricula, which is mostly beholden to big industrial agribusiness interests anyway. 'Resistance' is Jager's conjuring word. These farms 'are resisting soulless totalitarian tendencies' a thousand different ways. Some begin in classic subsistence, alternative hippy farms, some in family farms that began by pioneering necessity on small land grants; some remain small, some become fairly large like, say, the cooperatives modernizing the production and distribution of 'craft' products like maple syrup. You can't plan for farms like these, or organize a culture's economics to encourage them, since planning and economic efficiency are always prejudiced for scale. But you can praise the praise of alternative agriculture to be found in classic Greek, Roman, European Romantic and early American Jeffersonian writings as Jager does. And you can write poems in its praise as does Wendell Berry, and preach its gospel with the fervent expertise of Wes Jackson, and keep the spirit alive. Jager wonders why Americans favor the term 'farmers' over the term 'husbandmen' the latter of which he thinks better suits the practice of good stewardship on the land. He does the etymological digging to discover the term 'farmer' came with a built-in connotation of farming for business. This makes even its use in the phrase 'alternative farmer' subversive down in the roots.

Given that it does have a gist, the book is more a sampler than a full course meal. Almost every chapter pursues its own line of thinking, from etymology to literary history to statistics to almost novelistic evocations of families sitting around cluttered tables on their farms figuring out their next clever thrust into the soft underbelly of Big Agribusiness. The one bit I did not like personally was Jager's harsh criticism of Henry David Thoreau's harsh assessment of the mostly subsistence farms he knew from his travels

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through Concord—where men trafficked in cattle hides to get the money they needed to buy leather shoelaces. Thoreau made fun of anyone who seemed silly from his tight self-containment. But that is just a sample of one thing I found too piquant for my taste. Here's a book for the readers of this journal for your stimulation and pleasure, even if you decide there is little in here to fold into your footnotes.

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doi:10.1017/S1742170507001494

Eat Here: Reclaiming Homegrown Pleasures in a Global Supermarket. By Brian Halweil. 2004. W.W. Norton & Company, London and Worldwatch Institute, Washington, DC. xii+236 p. US$13.95, ISBN 0-393-32664-0, paper.

Eat Here is a well-written, engaging look at the problems that have accompanied the rise of the now-dominant global food system. Author Brian Halweil makes a case for shifting back to local food systems. The argument is presented in nine chapters, each pairing analysis of myriad food system issues with brief case examples of healthier, more sustainable and equitable alternatives currently in place around the world. This approach succeeds in both educating and inspiring the reader.

One of the strengths of this book is the use of creative terminology to bring concepts to life. Chapter 1 introduces us to the overall theme by contrasting the local and regionally produced foods at the Centreville Farmer's Market in Lincoln, Nebraska with the anonymous, 'travel-weary foods' across town in the super Wal-Mart. In Chapter 2 we meet 'transcontinental lettuce' and 'jet-lagged fruits' as Halweil continues tracing the rise of the modern food distribution system. These introductory chapters also begin to make the case for 'food democracy' and rebuilding the local foodshed, 'that sphere of land, people, and businesses that provides a community or region with its food'.

The food industry's 'culture of bigness' is analyzed in Chapter 3. The development of this culture has been accompanied by the precipitous decline of the farmer's share of the food dollar from forty cents in 1910 to less than eight cents in 1997. Halweil identifies major causes of this decline as national and global economic policies (including transportation and subsidies), industry marketing and lobbying efforts, and the concentration of various layers of agribusiness (especially the seed, trade, meat and milk, and retail sectors). This chapter makes one of the key points of the book—that this culture of bigness has also encouraged a 'culture of sameness' which, according to Yale historian Steven Stoll (as quoted by Halweil), marked 'the end of seasonality' which 'has only made it easier for people to forget that their food comes from specific environments.'

Chapter 4 asks, 'Where Have All the Farmers Gone?' and elaborates on the issues introduced in the previous chapter. Herein a description of farm loss and the decline of agricultural work due to mechanization, consolidation, and decreases in crop prices gives way to a discussion of the social effects of 'de-agrarianization.' Chapter 5 goes on to address the loss of agricultural biodiversity and begins to outline techniques for restoring local self-sufficiency, in both rural and urban areas.

The focus of Chapter 6 is on 'Taking Back the Market.' It opens with the story of The Farmer's Diner in Barre, VT, a classic diner with a 'new' twist. Founder Tod Murphy endeavors to provide as much food from local producers (within 70 miles) as possible, having reached the 65% mark and aiming for 100%. The chapter outlines a variety of local food marketing models including farmer's markets, farmer cooperatives, CSAs, value-added processing, farm shops, farm-to-school, restaurant, and other institutional buyer programs. This is the most exciting chapter of the book. It brings the local foodshed idea to life and makes it seem not only possible, but inevitable.

However, the following chapter quickly brings us down to earth with a look at the barriers to these solutions. Chief among them is the concentration of the processing, marketing, and retailing components of the food system. According to Halweil, viable local food systems require the rebuilding of links (such as canneries, butchers, bakeries, etc.) between producers and consumers. The difficulties inherent in this process are evident in the ongoing struggles of The Farmer's Diner. In August 2005, after the publication of *Eat Here*, the diner closed abruptly for 'retooling and regeneration' [Palmer, Robin. 2005. 'Farmer's Diner shuts its doors.' *Times Argus*, August 10. Available at Website: http://www.timesargus.com/apps/pbcs.dll/article?AID=2005508100339 (retrieved on 31 May 2006)] with plans to reopen in October 2005. Still closed in May 2006, a phone message indicates plans to reopen in a new location in July 2006.

Chapter 7 does offer some specific suggestions for rebuilding the mid-level food system. One such idea is the local commercial kitchen created to incubate local value-added food processing companies and supporting food entrepreneurs. Halweil also acknowledges that many of the solutions must be made at the national and international policy levels. The chapter ends with policy recommendations largely focused on consolidation, commodity payments, and world trade rules. This sets the stage for the focus of Chapter 8 on the international Slow Food movement, including an important discussion of the class issues and accusations of elitism often leveled at this and other local or organic food movements.

This book is clearly a call to action with appendices on 'What Individuals Can Do' and information on 'Organizations Working to Rebuild Local Foodsheds.' Each chapter ends with a section entitled 'Breaking Ground' in which Halweil briefly describes a community, company, or

program that models a local food system component that could presumably be replicated elsewhere. These inspirational vignettes include farm cooperatives in Nairobi, an organic food, fabric and herbal medicine company in Cairo, and agricultural tourism in Norway. Inspiring stories are also peppered throughout the text and provide detailed examples of programs like farmer's markets, CSAs, buy local campaigns, farm-to-school initiatives, and local food policy councils.

Halweil concludes the book with a reminder that growing concerns about food safety, energy costs, health, security and access, sprawl, rural community viability, cultural heritage, the environment and democracy are powerful motivations for the shifting of foodways from global to local. As he revisits the major themes of the book he shares a story from his own community at the eastern end of Long Island that highlights the counterintuitiveness of the current system:

> People in the food business still remember, with some embarrassment, when the attacks of September 11 shut down all traffic in and out of New York City, and many East End restaurants closed because they were without suppliers. The sight of fishless sushi houses surrounded by fishing fleets and salad-less restaurants surrounded by fields of lettuce and tomatoes prompted many chefs to visit a farm or dock.

Eat Here is journalistic in style and upbeat in tone. It provides both anecdotal and statistical data to back up each argument and remains accessible to a general audience. Endnotes are concentrated at the back of the book followed by a helpful and extensive index. The text contains seven figures and one sidebar. Though there are few such visual summaries of information contained in the book, they are well-chosen and enhance and support the arguments being presented. The book would serve equally well as a tool for community groups and a text for the undergraduate classroom.

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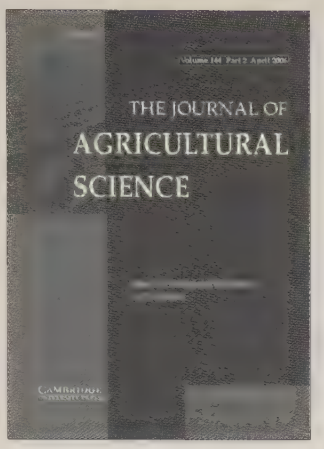

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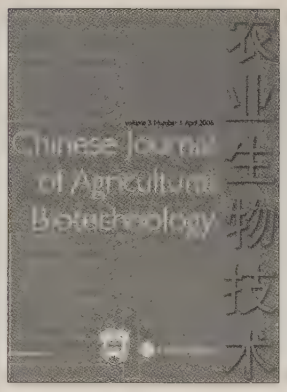

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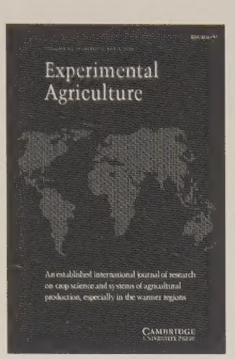
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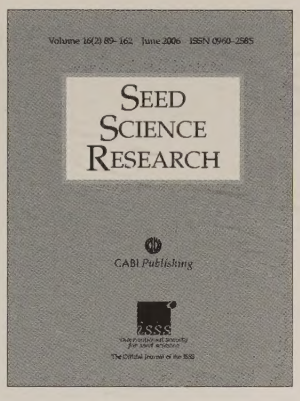

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Examples:

1. Leopold, A. 1991. The farmer as a conservationist. In S.L. Flader and J.B. Callicott (eds). The River of the Mother of God and Other Essays by Aldo Leopold. University of Wisconsin Press, Madison, WI. p. 255–265.
2. Brink, R.H. Jr, Dubach, P., and Lynch, D.I., 1960. Measurement of carbohydrates in soil hydrolyzates with anthrone. Soil Science 89:157–166.
3. Greenland, D.J., and Szabolcs, I., (eds). 1994. Soil Resilience and Sustainable Land Use. CAB International, Wallingford, UK.
4. Arshad, M.A., and Coen, G.M., 1992. Characterization of soil quality: Physical and chemical criteria. American Journal of Alternative Agriculture 7:25–31.
5. Coale, F.J. 1996. Descriptions of the soil test interpretive categories used by the University of Maryland Soil Testing Laboratory. SFM-3. University of Maryland, College Park.

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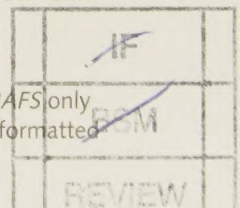

Renewable Agriculture and Food Systems

Volume 22 Number 1 March 2007

Research Papers

The influence of a shift from conventional to organic olive farming on soil management and erosion risk in southern Spain
Jessica Milgroom, María Auxiliadora Soriano, José M. Garrido, José A. Gómez and Elías Fereres 1

A new conservation education delivery system
Sharon Clancy and Britt Jacobson 11

The importance of farmers' markets for West Virginia direct marketers
Cheryl Brown, Stacy M. Miller, Deborah A. Boone, Harry N. Boone Jr, Stacy A. Gartin and Thomas R. McConnell 20

Six-year comparison between organic, IPM and conventional cotton production systems in the Northern San Joaquin Valley, California
Sean L. Swezey, Polly Goldman, Janet Bryer and Diego Nieto 30

Influence of cover crops and soil amendments on okra (*Abelmoschus esculentus* L.) production and soil nematodes
Qingren Wang, Yuncong Li, Waldemar Klassen and Zafar Handoo 41

Consumer interactions and influences on farmers' market vendors
Alan R. Hunt 54

Farm woodlots in northern New England, USA: Characteristics, management, and contributions to the whole farm system
A.F. Egan 67

Book Reviews 74

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